"QUANTIFICATION OF THE CORNEAL ASTIGMATISM FOLLOWING EXTRACAPSULAR CATARACT EXTRACTION VS SMALL INCISION CATARACT SURGERY WITH INTRAOCULAR LENS IMPLANTATION" - A RANDOMISED CONTROLLED TRIAL

By

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Under the Guidance of

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LIST OF ABBREVIATIONS

ECCE	Extracapsular cataract extraction
SICS	Small incision cataract surgery
WTR	With the rule astigmatism
ATR	Against the rule astigmatism
IOP	Intra Ocular Pressure
SD	Standard Deviation
Å	Angstrom
µ	Micron
PMMA	Polymethylmethacrylate
PCIOL	Posterior chamber intraocular lens
DF	Degrees of freedom

ABSTRACT

Background and Objectives:

To quantify and compare the induced corneal astigmatism in extracapsular cataract extraction and small incision cataract surgery.

Methods:

This was a randomized control study in which 120 patients with senile cataract were divided into 2 groups of 60 each. Patients in group A underwent manual small incision cataract surgery with posterior chamber intraocular lens implantation (with superior straight 6mm incision). Patients in group B underwent extracapsular cataract extraction with posterior chamber intraocular lens implantation (with superior 6mm mid limbal incision and 3 interrupted 10-0 nylon sutures. Keratometric readings were taken preoperatively as well as at 1-2 weeks, 6-8 weeks and 10-12 weeks postoperatively. Surgically induced astigmatism was calculated using the preoperative and postoperative keratometry readings by the vector method.

Results:

The number of patients with a surgically induced astigmatism of <1.5D was 77% in group A and 70% in group B. The average surgically induced astigmatism at 3 months postoperatively in group A (SICS) was -1.13 ± 1.04 D and -1.29 ± 0.95 D in group B (ECCE). This difference was not found to be statistically significant (unpaired t test= 0.895, DF=118, P=0.372).

Conclusion:

The average SIA in SICS was -1.13 ± 1.04 D and that of ECCE was -1.29 ± 0.95D. Since the difference in the surgically induced astigmatism between the two groups was not statistically significant, this study demonstrated that by using a 6mm mid limbal incision and placing only 3 interrupted 10-0 nylon sutures in extracapsular cataract extraction, the surgically induced astigmatism can be reduced and can be made comparable to that of small incision cataract surgery with a 6mm superior self sealing corneoscleral tunnel incision.

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INTRODUCTION

No other surgical speciality has been so dominated by a single operation as has ophthalmology by cataract extraction. There is no other type of ocular surgery concerning which ophthalmologists in general are better informed and have more definite, if sometimes divergent opinions. No other form of ophthalmic procedure is so gratifying to both the patient and doctor when sight is restored.

Approximately 18 million people worldwide are blind from bilateral mature cataracts. Despite what modern technology has done to advance the treatment of cataracts, the greatest challenge in our field continues to be the large backlog of cataract blindness in developing countries [(1)].

Age related cataract is the commonest cause of preventable blindness in the world. In India, about 80% of the blindness is attributed to cataract, the management for which remains surgical due to the poor understanding of its exact pathogenesis.

Initially, cataract surgery was aimed at treating the blindness only. Now it has progressed to being a refractive procedure that aims for postoperative emmetropia. Postoperative better quality of vision and early visual rehabilitation are the two important parameters which determine the success of modern cataract surgery. These two parameters in turn, depend on the severity of postoperative astigmatism.

With the introduction of operating microscopes, development of precise microsurgical instruments and availability of ideally designed posterior chamber intraocular lenses, conventional extracapsular cataract extraction (ECCE) became the preferred method of cataract extraction until the past decade [(2)]. However, the major

drawbacks with this procedure were a large incision with subsequent suturing and astigmatism.

The invention of the technique of phacoemulsification by Charles Kelman in 1967 and learning the technique of the self sealing wound resolved the above mentioned problems associated with conventional ECCE and began the era of sutureless small incision cataract surgery.[3]

However, cost, both in terms of equipment and training has limited its use in the developing world. Thus there is a dichotomy with different standards of care between the developed and the developing world. [4]

High quality, high volume cataract surgery is needed in community eye care centres to effectively manage the large backlog of cataract blindness. Manual small incision cataract surgery in which the nucleus is removed through a 6-6.5mm scleral tunnel is claimed to have similar advantages to phacoemulsification [5,6]. It is thought that the smaller wound heals faster than a conventional incision leading to less astigmatism and a better uncorrected visual acuity [7, 8].

In 1864, Donders noted that "To the very ordinary causes of altered, and consequently irregular arching of the cornea, belongs the extraction of cataract". With the introduction of the keratometer in 1881, surgeons could measure corneal astigmatism reliably, yet without techniques to control surgically induced astigmatism, clinicians showed little interest in the keratometer. [9]

The development of non invasive monitoring by topographical analysis and keratometry represent a new dimension in the precise and appropriate correction of

astigmatism. Postoperative astigmatism remains an integral part of cataract surgery, which depends on factors like:

- Type of incision
- Length of incision
- Position of incision
- Type of closure of incision
- Tightness/looseness of sutures
- Distance between two sutures, etc

Improvements in the surgical technique of cataract extraction and the desire to minimise complications have focused attention on the cataract incision and its closure.[10] Understanding the cataract incision and wound closure aids in giving prompt vision after cataract surgery. If an incision's effect on corneal curvature were to be predictable, a surgeon could select a particular incision to reduce the postoperative astigmatism [(11)]. This is important as many patients do not wear or cannot afford spectacles after surgery, which means that it is their uncorrected visual acuity is what they rely on to carry out their everyday functions. [(7)]

The average response of the cornea to an incision is predictable as a function of time after surgery. Change in corneal curvature after an incision is continuous until the wound stabilises; the rate, magnitude and duration of this change have not been quantified for common incisions of cataract.[12]

In view of this we have endeavoured to compare the corneal astigmatism following conventional extracapsular cataract extraction and small incision cataract surgery.

OBJECTIVE OF THE STUDY

To quantify and compare the induced corneal astigmatism in extracapsular cataract extraction and small incision cataract surgery.

REVIEW OF LITERATURE

HISTORICAL ASPECTS

Earliest authentic records of treating cataract come from ancient Hindu medicine. Long before Christ, Susrutha in India was practising couching and he gave the foundation of surgery based on anatomical dissections. He gave an excellent account of his technique of couching as well as an outline of the postoperative care of patients in his Susrutha Samhitha.

Jacques Daviel (1692-1762) inaugurated a revolution in ophthalmology by extracting the lens from its natural position. However, this technique was a complicated one, until George la Faye (1699-1781) who simplified the technique and it became practicable.

Samuel Sharp (1753) of London gets the credit of removing a cataractous lens with the capsule intact by thumb and pressure technique.

Later, other techniques of intracapsular cataract extraction are described by Ignacio Barraquer (1917-1924) of Barcelona who designed the erisiphake controlled by electric pump. T. Krwawicz Lublen (1961) in Poland invented cryo surgical probe for intracapsular extraction.

Zonular destruction by dissolving it with an enzyme alpha chymotrypsin was described by J. Barraquer in 1958.

Initially there were no sutures used in cataract surgery. Sutures as a safety measure for wound closure were introduced by Henry Williams of New Maryland in 1867 who first inserted a single corneo scleral suture. But it was not until the 1930s

when interest was renewed in the use of corneoscleral sutures by Stallard (1933), Lindner (1936), Verhoeff (1936) and Mclean (1940). Most of the surgeons neither accepted nor used corneoscleral sutures in the practice of cataract surgery probably due partly to lack of fine needles and suture material and partly to the reluctance at that time to prolong an operation without the aid of periocular anaesthesia.

The next milestone in cataract surgery was the use of magnification. Magnification during surgery was achieved by various techniques like magnifying spectacles, binocular loupes. Littmann introduced the surgical microscope for the first time.

Initially, the corneoscleral section was made up to 180 degrees using an ab interno technique using Von Graefe's knife. Later on, the incision length reduced to about 120 degrees (8-12mm) in planned conventional ECCE. Then, the most exciting innovation in cataract surgery was made i.e.phacoemulsification which was introduced by Kelman in 1967. The advantage of this procedure is the removal of cataract through a 3mm incision eliminating the complications of large incision cataract surgery.

In the evolution of cataract surgery, manual small incision cataract surgery was a later addition, much after phacoemulsification became popular technique. In the early 1980s, phacoemulsification was the only available technique for achieving a small incision. Alternative methods were then introduced and Keener in 1983 used a constricted wire loop. Fry gave the phacosandwhich technique and Peter Kansas proposed the technique of phacosection. But it was the development of the sclerocorneal pocket tunnel which revolutionized the non-phaco manual small incision cataract surgery (SICS) [13, 14].

In the usual superior incision for a cataract surgery, a fairly regular inverse astigmatism results, a circumstance first noted by Donders in 1864. It was first accurately measured keratometrically by Von Reuss and Virchoff in 1869.

The work on post operative astigmatism was done by Van Lint(1914), Alexides(1920), Andre(1923), Tron (1925), Alajmo (1950), Floyd (1951), Frano Card(1958) and many others. But while assessing the post operative astigmatism, nobody looked into the aspect of preoperative astigmatism. As Norman S. Jaffe says in his book on cataract surgery and its complications: "to my knowledge there has been no published series reporting exact quantitative difference between preoperative and postoperative corneal curvature".

First record of determination of central corneal radius by using its relationship with the size of image formed by reflection at its anterior surface was made by Schirner in 1916.

However, Von Helmholtz (1821-1894), the noted physicist and physiologist is credited with the development of the first keratometer (he called it the ophthalmometer) in 1854. On this principle, Javal and Schiotz in the 19th century refined the instrument and brought it to clinical use.

Recently, computerised surgical keratometers have come into use which helps in the apposition and tying the sutures and controlling the astigmatism.

ANATOMICAL AND PHYSIOLOGICAL ASPECTS[15]

The cornea is the first and most powerful lens of the optical system of the eye.

It is transparent and resembles a little watch glass. Its curvature is greater than the rest of the globe. Sulcus sclera separates it from the sclera. Cornea viewed from the front is elliptical, being 12mm in horizontal and 11mm in vertical diameter. From behind, cornea appears circular about 11.5mm in diameter.

Radius of curvature of the anterior surface of the cornea in the central region is 7.8mm. Rather wide range of variation from 7-8.5mm is compatible with good visual function.

Refractive index of cornea is 1.376 which gives the average anterior central region, a refractive power of 48.8D. The concave posterior surface of the cornea faces the aqueous which has a lower refractive index (1.336). The refractive power of this surface is-5.8D giving the entire cornea a refractive power of 43D.

Corneal curvature changes somewhat with advancement of age. It is spherical in infancy and changes to with the rule astigmatism during childhood and adolescence. It again becomes more spherical in middle age. In senility, astigmatism is against the rule.

Temperature in the cornea is relatively low. In the rabbits for example, the difference between cornea and that of iris amounts to 5 degrees centigrade.

Layers of the cornea:

1. *Epithelium:* Consists of 5 or 6 layers of stratified squamous epithelium resting on a very delicate argyrophilic basement membrane. It is about 50 µ in thickness. The deeper layer is basal cells which stand in palisade manner in perfect alignment on a basement membrane.

2. *Bowman's membrane:* Measures 8-14 µ in thickness being somewhat thicker in the peripheral third. This is composed of collagen and contains no cells. Towards the periphery, it becomes thinner and arrangement of fibres looser and collagen gradually merges with that of conjunctiva. Collagen fibrils in the bowman's layer are smaller and uniform in thickness and measure between 240Å and 270Å. Bowman's membrane once destroyed will not regenerate and thus gives rise to a permanent defect.

3. *Stroma:* It is 0.5mm in thickness. It is composed of modified connective tissue, of which the constituents have very nearly the same refractive index so that in the perfectly fresh condition it is difficult to make out any indications of structure. Among the lamellae of the cornea are a considerable number of fixed cells, corneal fibroblasts or keratocytes, wandering macrophages. Occasionally, lymphocytes or polymorphonuclear leucocytes are seen.

4. *Descemet's membrane:* it is a strong, homogenous and very resistant membrane. It is 10-12µ thick and sharply defined from the stroma. There is in fact a plane of separation between them which is used in lamellar keratoplasty and sclerocorneal tunnel incisions for cataract surgery. When it is incised, it gapes and curls backwards indicating some elasticity in this

layer. In the periphery, it bends to form schwalbe's line to which the trabecular meshwork is attaches anteriorly. When this membrane is destroyed, unlike bowman's membrane, it is regenerated by the endothelium.

5. *Endothelium:* It is a very precious layer for the anterior segment surgeon. Technique if surgery is modified to see that minimum damage and insult is done to the endothelium. It is the most posterior layer of the cornea and consists of a single layer of flattened epithelial like cells, continuous around the angle of the AC. With slit lamp, endothelium can be visualised. It is the whole site in the whole body where endothelium cab ne seen and studied under magnification. Specular microscopy helps to evaluate the endothelial status allowing an objective estimation of endothelial cell loss.

The Limbus:

With knowledge of surgical anatomy of the limbus, the surgeon can maintain orientation during any procedure and using an incision in the correct place, complications like hyphema and postoperative astigmatism can be reduced.

Surgical limbus is 2mm wide which marks the transition between the cornea on one hand and the conjunctiva, the episcleral tissue and sclera on the other side. Kasner has linked the surgical anatomy of the limbus to a tennis court. Junction of blue and white areas is the net that overlies the Schwalbe's line [(16)].

Anterior base line overlies the termination of bowman's membrane. This is the anterior border of the limbus. Posterior baseline overlies the scleral spur or root of

iris. This is the posterior border of the limbus. In cataract surgery, the incision can be corneal, anterior limbal, mid limbal, posterior limbal or scleral.

POSTOPERATIVE CORNEAL ASTIGMATISM

Basics of astigmatism

Astigmatism is an error of refraction in which a point of light cannot be made to produce a punctuate image upon the retina by a correcting spherical lens (Miller Stephen J. 1990) [17]

Irwin M Borigh (1970) defined astigmatism as a refractive condition in which a variation of power exists in the different meridians of the eye. Generally one meridian exhibits the greatest and the other the least power and these are known as principal meridians.

The term astigmatism is derived from the Latin word ‘stigma’ meaning a point. Thus, in astigmatism, a point object is not imaged as a point.

Classification of astigmatism [18]:

- Regular astigmatism
- With the rule
- Against the rule
- Oblique
- Bioblique
- Irregular astigmatism

Regular astigmatism:

In regular astigmatism, direction of greatest and least curvatures of the cornea lies at right angles to one another. It is of the following types:

- *With the rule astigmatism:* the meridian of least curvature makes an angle of less than 30° with the vertical plane OR the meridian with the greatest refractive power is near vertical in orientation or close to 90°.

- *Against the rule astigmatism:* the meridian of least curvature makes an angle of less than 30° with the vertical plane OR the meridian with the greatest refractive power is near horizontal in orientation or close to 180°.

- *Oblique astigmatism:* the principal meridians are greater than 30° away from vertical or horizontal meridian but still at right angles to each other

- *Bioblique astigmatism:* the 2 principal meridia are not at right angles to each other

Irregular astigmatism:

Refraction in different meridians conforms to no geometrical plane and refracted rays have no planes of symmetry.

The importance of astigmatism lies in the fact that, it is particularly liable to cause the worst forms of asthenopia. It results in eye ache, headache because of blurring of vision. The astigmatism produced by the contraction of scar of cataract surgery results in flattening of the cornea in the meridian at right angle to the wound. This change in corneal curvature continues to alter for some weeks after surgery so

final spectacles should be ordered at least 6 weeks postoperatively. (Abrams D 1993)[19]

Factors affecting postoperative astigmatism in conventional ECCE

i. Nature of incision: size, configuration, site

ii. Scleral cauterization

iii. Suturing

i. Nature of incision

a) Site of incision:

Corneal incision causes greatest astigmatism, limbal incision intermediate and scleral incision least.

Van Rij and Waring (1984) found that in corneal incisions, a suture taken at 12 o'clock steepened the vertical meridian and flattened the horizontal meridian. [20]

Wishart MS, PK Wishart and ZJ Gregor (1986) found that mid limbal incisions between 6 and 13 weeks showed a marked reduction in astigmatism and a shift of astigmatism from WTR to ATR. However, they also found that eyes with limbal incisions showed more inflammation than eyes with corneal incisions [21]

Charleux (1987) observed that a greater suture induced WTR astigmatism developed in corneal as compared to scleral incisions using 10-0 Nylon. [22]

Jaffe NS (1990) in a study of 662 patients found higher postoperative astigmatism with anterior limbal incision as compared to mid limbal incision. [16]

Surendra Basti (1993) found that post operative astigmatism was maximum with corneal incision and minimal with scleral incision, but bleeding and intraoperative iris prolapsed due to scleral incision was maximum. [23]

Thrasher and Boerner (1984) found that posteriorly placed wounds induced little change in the pre existing astigmatism while astigmatism was greater in anteriorly placed incisions [24]

b) Length of incision

A corneal incision must be larger than a scleral incision to provide equal working space in the AC. By the same reasoning, an anterior limbal incision must be larger than posterior limbal incision.

Reading Veronica M (1984) in a study of 40 cataract extractions found that smaller incisions had a steeper curvature of the vertical meridian while larger incisions had a steeper curvature of the horizontal meridian which tended to remain steeper, while the vertical meridian varied little. [11]

Flaharty and Siepser (1989) in a study of 100 cadaveric eyes found that large incisions caused twice as much astigmatism as small incisions. [25]

A very short incision, especially when sutured with nylon tends to steepen the axis that passes through the arc of the incision and flattens the perpendicular meridian.

ii. Scleral cauterization:

It cause shrinkage of the collagen and may result in with the rule astigmatism

iii. Suturing

a) Type of suture material:

Synthetic sutures tend to cause wound compression and lead to with the rule astigmatism.

Absorbable sutures tend to produce a surgically induced astigmatism, ATR, although the suture induced astigmatism is usually WTR during the early post operative period.

Wishart and Gregor (1986) found that with 10-0 monofilament nylon, there was high WTR astigmatism 2 weeks postoperatively which gradually decreased but was still with the rule at 26 weeks. [(21)]

Thomas Cravy (1989) in a study of 397 cataract extractions that hydrolysable sutures like 10-0 nylon resulted in a late ATR astigmatism, since they were unable to retain their tensile strength more than 1 year, while non hydrolysable sutures like prolene and merisilene were able to retain their elasticity for a longer time. Thus though all cataract incisions eventually showed an ATR astigmatism between 2-4 years, amount of astigmatism was less in non hydrolysable sutures. [(26)]

With nylon sutures, after an initial period of stabilisation lasting up to 2 weeks, the suture induced astigmatism changes little with time. The initial decay is caused by the decreased wound edema and production of a cicatrix.

b) Technique of suturing:

Suturing aims at achieving full thickness apposition without causing astigmatism or secondary reaction from the suture.

Suturing may be:

- Interrupted, single or X shaped
- Continuous, single running, double running or shoelace pattern

Interrupted sutures can have variable induced tension to compensate for incision induced or pre existing astigmatism and the advantage of possible release to control post operative astigmatism. Single running sutures induce lateral shift to the wound when oriented radially with unpredictable astigmatism. Double running sutures contribute to astigmatism by compression and in single running sutures, rotational and oblique components also act.

According to **Gullapalli N Rao (1993),** interrupted sutures are easy to remove, wound is stable and less amount of later ATR drift occurs while, with continuous sutures there is ease of placement, less time consumption but large amount of ATR drift. [(27)]

Ivekovic, Mandic and Skegro (1994) analysed the occurrence and changes of postoperative astigmatism in 3 groups of patients after they performed ECCE regarding the type of applied sutures: single, continuous double row and combined suture. The quickest decrease in astigmatism was recorded in the application of combined suture. [(28)]

Storr, Vangsted and Perriard (1994) investigated the long term course of surgically induced astigmatism after ECCE. 61 eyes were followed for 36 months. [29] The results were:

- Postoperative astigmatism was significantly increased in all eyes after 1 week and 3 months but decreased in all eyes after 1 week and 3 months but decreased in time approaching preoperative values in 3 years.

- Surgically induced astigmatism was WTR at 1 week and 3 months but turns ATR in time in both groups. They concluded that surgically induced astigmatism is a dynamic feature showing changes in size and axis even 1-3 years postoperatively

c) Suture bite length:

The bite of suture should be 0.5 -1.5mm in length separated by a distance that equals their length, should be equivalent and tied with the same degree of tension. Wrinkling of cornea occurs if the sutures are too tight.

According to **Gullapalli N Rao (1993),** the length of the suture produces a zone of compression. Long sutures placed close to each other create significant tissue compression leading to with the rule astigmatism. [27]

d) Suture depth:

Swinger CA (1987) stated that ideally 10=0 sutures are placed just anterior to the Descemet's membrane to allow full depth wound apposition. Superficial sutures allow slippage in deeper parts of wound causing ATR astigmatism. [30]

A vertical mismatch in depth of the 2 edges also causes astigmatism. Deep to superficial suturing from corneal to scleral edge causes ATR astigmatism while deep to superficial from scleral to corneal edge causes WTR astigmatism.

e) Tightness/looseness of suture:

Tight sutures increase wound compression causing WTR astigmatism while loose sutures permit wound gape with ATR astigmatism.

Flaharty Patrick (1989) found that tight sutures caused 2-3 times more astigmatism when compared to loose sutures in cadaveric eyes. [25]

f) Suture orientation:

Sutures are ideally place radially. Non radial sutures cause irregular astigmatism because of areas of compression and gape

Factors affecting postoperative astigmatism in manual SICS[31]

1. Preoperative factor:

The final astigmatic error depends to a large extent on preoperative astigmatism in a significant number of patients

2. Cautery:

The long term effects of cautery may give rise to unacceptable levels of postoperative astigmatism by 2 mechanisms:

- Thermal injury cross linkage of collagen fibres uneven shrinkage of wound usually WTR astigmatism (Troutman 1992)

- Closure of capillaries and small vessels which affect the healing process.

  Proper dissection of tissues precludes use of cautery. If at all necessary, it should be used sparingly.

The incision

As a general rule, the smaller and more posterior the incision, the less induced astigmatism there is. Conversely, a longer and more anterior incision can be expected to induce a greater astigmatic change.

Surgically induced corneal astigmatism depends largely on how the incision is created and how it is closed, as the incision is not only a port of entry but also a focus for corneal stability.

With SICS incisions ,which are approximately 6-7 mm in length, it is probably not possible to avoid all induced astigmatism.

With incision longer than 3-4mm, multiple factors are involved and their interaction makes the subject very complex, the various factors are site of incision, length of incision, plane of incision, tissue elasticity, tissue tensile strength and wound healing.

Where the wound requires suturing, tightness, suture length, depth of suture bites and number of sutures play a role in inducing astigmatism.

Incisional funnel

The relationship between shape of external incision and astigmatism can be derived from a couple of mathematical relationships concerning incision and corneal astigmatism. These are:

- The corneal astigmatism is directly proportional to the cube of the length of the incision.
- Corneal astigmatism is inversely proportional to the distance of incision form the limbus

Through a complete description of these interactions, Paul S Koch arrived at a relationship which he calls “the incisional funnel”. It is formed by an imaginary pair of lines approximately 3mm apart at the limbus that diverge from the limbus, separating as the distance from the limbus increases.

Incisions made in this funnel will be astigmatically neutral. Short incisions can be made closer to the limbus and longer ones further away, and all will have equivalent corneal stability.

Moving the linear incision further away from the limbus will make it more stable, but consequent increase in the length of the scleral tunnel restricts the lateral movement of the instruments (“oar locking”)

3. Location of the incision:

In SICS, the incision id made 2-3 mm behind the limbus which decreases the surgically induced astigmatism. Apart from this it gives a greater wound healing surface and a more water tight seal.

Disadvantages of posterior incision includes greater risk of premature entry and postoperative hyphema.

4. Configuration of external incision:

- ***Curvilinear incision (Smile incision):*** traditional cataract incisions have been limbus parallel curvilinear incisions. With this incision, there is nothing to prevent the inferior edge from falling away from the superior edge. This wound gape potential is the cause for the high ATR astigmatism. This prolongs the visual rehabilitation of the patient.

- ***Straight incision:*** the 2 extreme points of the incision are secured in the sclera and the inferior edge directly adjacent to the end points of the incision cannot sag. Hence, the induced astigmatism is limited to the degree of instability of the middle of the incision. This incision induces lesser astigmatism than the smile incision. A straight incision of smaller length induces less astigmatic change if it is in the incisional funnel. A longer incision has to be moved posteriorly to achieve the same effect.

- ***Frown incision:*** if the ends are place further superior on the sclera, then the entire incision falls in the incisional funnel. The superior wound edge acts as though there are slings hanging down which are supporting the ends of the

incision. Therefore, the inferior edge of the incision would not sag away from the superior edge of the incision. This incision produces the least astigmatism.

- ***Chevron 'V' shaped incision:*** incision made on the same principles as the frown incision. It is in the form an inverted V with the apex of the V near the limbus and limbs away from it.

5. Length of external incision:

Length of the external incision in SICS is around 5.5-7mm. It varies with size, grade of nucleus and method used to deliver it out of the AC.

Paul Ernest studied the astigmatism induced by 12mm, 7mm and 4mm incisions. At 3 months postoperatively, the induced astigmatism was 3.09D, 1.92D and 1.05D respectively. [(32)]

6. Size of internal entry:

When an incision is made on the scleral surface, then it is common to see the 2 edges separate from each other. This is a physiological reaction to 2 factors: the natural elasticity of the sclera and scleral shrinkage due to cautery. The incisional gape does not affect corneal astigmatism. Only entry into the anterior chamber will have an effect on astigmatism as it permits the cornea to change shape.

Even though the size of the external incision is 6mm or less in a majority of cases, the reason for the higher incidence of astigmatism is due to wider internal entry(as it is approximately 1mm longer on each side when compared to the external incision.

7. Orientation of the wound:

As the corneas flattens along the meridian of scleral section, incision can be fashioned on the steep meridian. In patients with pre existing ATR astigmatism, temporal site can be chosen. In a temporal incision, the distance is about 1mm more from the optical centre as compared to the superior incision. As a result, surgically induced astigmatism is comparatively less with temporal incisions.

8. Effect of sutures:

A longer tunnel is usually closed with sutures. From the astigmatic point of view, any incision greater than 6.5-7 mm must be closed with sutures. These sutures bring the wound edges back together but the sutures are tight enough to compress tissue at wound edges, increasing corneal curvature in the axis of the incision thereby inducing with the rule astigmatism. This induced astigmatism is temporary and degrades postoperatively. If the sutures fail to reapproximate the edges until secure tissue healing occurs, permanent ATR astigmatism will result.

Another way to close the wound is to place a horizontal suture. This makes the incision water tight and gives a more physiological closure. It is also less prone to disturb the internal entry site and hence causes less astigmatism.

George R et al (2005) compared the surgically induced astigmatism following conventional ECCE and SICS at 6 weeks postoperatively and concluded that the mean surgically induced astigmatism in ECCE was 1.77D and 1.17D for SICS.[33]

Vazquez LA and Panes so JL (1993) studied the surgically induced astigmatism in different cataract incisions and closures an 255 eyes and concluded

that a horizontal, 5mm sutureless scleral tunnel incision showed less induced astigmatism with more rapid stable refraction.[34]

Jaffe NS (1984) indicated that SICS gives better short term visual results than standard ECCE particularly before correction.[16]

Reading VM (1984) conducted a study to determine the magnitude of change in the corneal curvature after 5 different incisions of cataract, the postoperative astigmatism 6 weeks postoperatively in cases of conventional ECCE was found to be more than that in case of surgery done with a 6mm superior scleral incision.[11]

Measurement of corneal curvature[35]

1) Keratoscopes:

- Placido's disc: invented by Gode in 1847, this instrument is 20cm in diameter and forms an erect, virtual image of concentric rings a few millimetres behind the cornea after light from an attached or external source is reflected from the rings onto the cornea to be examined. The examiner views the image through a central hole usually with the aid of a positive lens to reduce accommodation and provide some magnification.

- Photokeratoscope: this involves photographically recording the ring patterns for later measurement and review. It was invented by Placido in 1880 and Gullstrand in 1896 developed the mathematical theory necessary for quantitative analysis. It provides information about corneal topography by photographing the imaged Placido's disc and measuring the displacement of each ring at many points. Earlier instruments had flat targets, but these produce an image curvature, which prevented all the images from being in

focus at once. Modern instruments have spherical, ellipsoidal, or cylindrical target planes.

- Astigmometer: manufactured by Keeler to control corneal astigmatism during suturing. A ring of a light emitting diode is mounted on the operating microscope in the focal plane of one eyepiece and the image formed by the cornea is viewed through the eyepiece. An astigmatic cornea produces an ellipsoidal image of lights. By tilting the ring of lights, the image can be made circular and the angle of tilt can be used to estimate the amount of astigmatism.

2) Keratometers:

The first keratometer was devised by Helmholtz in 1854. The instrument uses an image doubling technique to measure the radius of curvature and location of refracting surfaces of the eye. Javal and Schiotz in 1881, simplified the Helmholtz instrument by restricting its use to the measurement of corneal curvature and included the ability to measure surface astigmatism. Following this, the Bausch and Lomb keratometers have come into vogue. Although techniques were available to measure the radius of curvature by reflection, measurements on the eye were difficult because of image movement. Doubling the image, which involves separating the image beam into 2 parts and measuring the distance between the 2 images, eliminated this problem since the 2 images move together when the eye moves.

The Bausch and Lomb Keratometer

The instrument comprises a lamp system that illuminates the mires by a diagonal mirror. Light from the mire strikes the cornea producing an in age behind it.

The mire, having fixed dimensions, image size depends on the corneal radius. The image formed now acts as an object for the optical system.

Light from the object is gathered by an objective lens and focused to a plane further along the central axis.

A 4 aperture diaphragm is located near the objective lens. Beyond the diaphragm are 2 doubling prisms, one with base up and other with base out. The prism can be moved independently, parallel to the central axes of the instrument.

Light passing through the left aperture of the diaphragm is deviated by the base up prism to place one image above the control axis. Light passing through the right aperture is deviated by the base out prism placing the second image to the right of the control axis.

Light passing through the upper and lower apertures does not pass through either prism and an image is produced on the axis. The total area of upper and lower apertures as equal to the area of each of the apertures, making the brightness of all 3 images equal.

The upper and lower aperture also acts as Scheiner's disc, doubling the central image when the instrument is not properly focused on the central corneal mire image.

The eye piece lens gives a magnified view of the double images

Automated keratometer:

Here the reflected image of the target is focused onto a photodetector which measures the image size and the radius of curvature is computed. The target mires are illuminated with infra red light and an infrared photodetector is used. The image is

measured in many meridians and the power and axis of the major meridians in computed. As the performance here is quicker than ocular movements, no doubling device is needed.

Intraoperative keratometry:

Barraquer was the first surgeon to advocate the use of a keratometer during a surgical procedure.

Troutman developed a qualitative device that projects a series o dots onto the cornea in the form of a circle. In the presence of astigmatism, the circle is seen as an ellipse.

Terry was the first to develop a quantititative surgical keratometer. While some studies have shown intraoperative keratometry to reduce suture induced astigmatism, some have found a poor correlation between intraoperative keratometric readings and final postoperative astigmatism.

3) Computed corneal topology:

A computer screen simulates a piece of graph paper divided into many squares or pixels. Video camera signals are put into the computer resulting in an image on the screen. The curvature of the corneas that corresponds to the rings in every location of determined. A detailed map of the cornea is obtained in which values of corneal curvature at each location of the ring appear. These numerical values can be represented as colours maps where cooler colours represent flatter curves and warmer colours steeper areas.

MATERIALS AND METHODS

The present study was carried out to quantify and compare the induced corneal astigmatism in extracapsular cataract extraction and small incision cataract surgery. A total of 120 cases were taken up for the study who fulfilled the following inclusion criteria:

i. Patients between 50-80 years of age

ii. Patients undergoing surgery for cataract by conventional ECCE and Small incision cataract surgery

iii. Cases operated in KLES Prabhakar Kore Hospital, Belgaum

iv. Patients willing to give informed consent

The following patients were excluded from the study:

i. Patients developing intra/postoperative complications like vitreous loss

ii. Patients with any corneal pathology like degeneration, dystrophies, infections

iii. Patients unable to cooperate for pre and postoperative keratometry like mentally handicapped patients

iv. Patients with lens induced glaucoma

v. Traumatic cataract

After obtaining a written informed consent from 120 eligible patients, they were separated into 2 groups by computer generated blocks of two:

- Group A had 60 patients who underwent SICS with PCIOL implantation
- Group B had 60 patients who underwent ECCE with PCIOL implantation.

Preoperative evaluation was carried out in which all patients were subjected to detailed history, systemic and ocular examination.

Ocular examination consisted of:

1. Slit lamp examination with lens evaluation
2. Fundoscopy
3. Tonometry using Schiotz tonometer
4. Lacrimal patency test
5. Keratometry using Bausch and Lomb keratometer
6. A scan ultrasonography (to determine axial length of eyeball for IOL power calculation)

IOL power calculation was done with SRK2 formula.

Other investigations included:

1) Blood pressure

2) Urine examination for detection of sugar and albumin

Surgical technique:

The essential steps of **ECCE** were:

- Lids retracted with wire speculum
- Superior rectus bridle suture taken
- Fornix based conjunctival flap made
- Haemostasis achieved with ball cautery
- Partial thickness corneoscleral groove made at mid limbal line measuring 6mm in length.
- Anterior chamber entered
- Can opener anterior capsulotomy performed with a bent 26G disposable needle.
- Incision extended to 6mm in length with corneoscleral scissors in the groove.
- Hydrodissection performed with a cannula
- Nucleus prolapsed into anterior chamber.
- Delivery of nucleus with a wire vectis and dialer
- Cortical matter removed by Symcoe cannula
- Implantation of PMMA PCIOL of 6mm optic diameter into capsular bag
- Aspiration of viscoelastic

- Closure of incision with 3 interrupted radial 10-0 nylon sutures
- Injection of air bubble into AC
- Sub conjunctival injection of gentamycin(40mg) and dexamethasone(4mg)
- Pad and bandage applied

The essential steps of manual SICS were:

- Lids retracted with wire speculum
- Superior rectus bridle suture taken
- Fornix based conjunctival flap made
- Haemostasis achieved with ball cautery
- A 6.5mm superior partial thickness scleral groove made
- Crescent blade (2.6mm) used to dissect the corneoscleral tunnel
- Keratome blade (3.2mm) used to enter the AC through the tunnel
- Can opener anterior capsulotomy performed with a bent 26G disposable needle.
- Hydrodissection performed with a cannula
- Internal incision extended to 8mm with keratome blade
- Nucleus prolapsed into anterior chamber.
- Delivery of nucleus with a wire vectis and dialer

- Cortical matter removed by Symcoe cannula
- Implantation of PMMA PCIOL of 6mm optic diameter into capsular bag
- Aspiration of viscoelastic
- Injection of air bubble into AC
- Sub conjunctival injection of gentamycin(40mg) and dexamethasone(4mg)
- Pad and bandage applied

In both groups, ringer lactate solution was used as irrigating solution. Postoperatively, all patients received a course of topical antibiotics with steroids 6 times a day with a mydriatic or cycloplegic twice a day. Systemic antibiotics (ciprofloxacin 500mg) were given for 5 days.

Postoperative assessment was carried out at 1-2 weeks, 6-8 weeks and 10-12 weeks.

Ocular examination during the follow up involved assessing the following:

- **Vision**
- **Conjunctiva**:

Congestion (palpebral/bulbar), ciliary congestion, discharge, section/suture site, edges gaping/opposed, sutures intact

- **Cornea**: Clarity, presence of Descemet's folds
- **Anterior chamber** : Depth, clarity, presence of air bubble

- **Pupil** : Size and shape
- **Intraocular lens**: position
- **Keratometry** with Bausch and Lomb keratometer

Surgically induced astigmatism was calculated from the preoperative and postoperative keratometric readings using the vector method.

Blinding:

Patients were not informed of the type of intervention they would receive. Double blinding was not possible as the surgeon examining the patient during follow up visits cannot be masked to the size/location of the incision and the presence or absence of sutures in the wound, which will indicate the type of surgery.

OBSERVATIONS AND RESULTS

In this study, 120 patients who conformed to the inclusion criteria laid down were selected and were separated into 2 groups by computer generated blocks of two.

Group A had 60 patients who underwent manual SICS with implantation of posterior chamber intraocular lens and group B had 60 patients who underwent extracapsular cataract extraction with posterior chamber intraocular lens implantation.

1) Age distribution

As shown in Table 1, most patients of group A were in the range of 50-60 years (47%). In group B, 43% of the patients were in the range of 61-70 years. The mean age of the patients in group A was 63.41 years and that in group B was 64.6 years.(Table 2).

2) Sex distribution

In group A, most patients were male (58%) as seen in Table 3. A similar trend was seen in group B (Table 4) with 60% patients being male.

3) Preoperative astigmatism

Table 5 shows that in group A, 33 patients (55%) had ATR astigmatism (mean= -0.85D) and 22 patients (37%) had WTR astigmatism (mean= -0.84D). 5 patients (8%) had no preoperative astigmatism.

In group B, 23 patients (38%) had WTR astigmatism (mean= -0.96) while an equal number had ATR astigmatism (mean= -1.08D). 14 patients had no preoperative astigmatism (Table 6).

4) Postoperative astigmatism

In group A, 54 patients (90%) had ATR astigmatism (mean= -1.27D) while 6 patients (10%) had WTR astigmatism (mean= -0.67D) 12 weeks postoperatively as evidenced by Table 7.

In group B, 48 patients (80%) had WTR astigmatism (mean= -1.51D) and 10 patients (17%) had ATR astigmatism (mean= -0.85D). 2 patients had no astigmatism 12 weeks postoperatively (Table 8).

5) Comparison of the astigmatic change from preoperative to postoperative state

Table 9 shows a comparison between the astigmatic shift occurring postoperatively after manual SICS and ECCE.

In group A, of the 22 patients who had WTR astigmatism preoperatively, 5 patients (8%) continue to remain so postoperatively and 17 patients (28%) showed a postoperative ATR drift. Of the 33 patients in group A who had ATR preoperatively, 32 patients (53%) remained so postoperatively and 1 patient (2%) had a WTR drift. All the 5 patients (9%) who had no preoperative astigmatism developed ATR astigmatism (Table 9).

In group B, of the 23 patients who had WTR astigmatism, 21 patients (35%) continue to remain so postoperatively and 2 patients (3%) had a postoperative ATR drift. Of the 23 patients who had ATR astigmatism preoperatively, 6 of them (10%)

continue to remain so postoperatively, 15 patients (25%) had a postoperative WTR drift and 2 patients (3%) had no astigmatism postoperatively. Of the 14 patients who had no preoperative astigmatism in this group, 12 of them (21%) had a postoperative WTR drift and 2 of them (3%) had an ATR drift (Table 10).

6) Range of Surgically induced astigmatism

Table 11 shows the range of surgically induced astigmatism at the end of 12 weeks in patients who underwent manual SICS with PCIOL implantation. 4 patients (6%) had no surgically induced astigmatism (SIA), 16 patients (27%) had SIA in the range 0.25-0.5 D, 16 patients (27%) had SIA in the range 0.75-1.0 D, 10 patients (17%) had SIA in the range 1.25-1.5D, 8 patients (13%) had SIA in the range 1.75-2.0 D, 1 patient (2%) had SIA in the range 2.25-2.5D and only 5 patients (8%) had SIA greater than 2.5 D.

Table 12 shows the range of surgically induced astigmatism at the end of 12 weeks in patients who underwent ECCE with PCIOL implantation. 2 patients (3%) had no surgically induced astigmatism (SIA), 14 patients (24%) had SIA in the range 0.25-0.5 D, 15 patients (25%) had SIA in the range 0.75-1.0 D, 11 patients (18%) had SIA in the range 1.25-1.5D, 4 patients (7%) had SIA in the range 1.75-2.0 D, 11 patients (18%) had SIA in the range 2.25-2.5D and only 3 patients (5%) had SIA greater than 2.5 D.

7) Type of Surgically induced astigmatism

In group A, Table 13 shows that of the 60 patients, 16 (27%) developed WTR astigmatism with a mean of -1.12D and 40 patients (67%) developed ATR astigmatism with a mean of -1.08D. 4 patients (6%) had no SIA.

In group B, Table 14 shows that of the 60 patients, 37 (62%) developed WTR astigmatism with a mean of -1.31D and 21 patients (35%) developed ATR astigmatism with a mean of -1.46D. 2 patients (3%) had no SIA.

8) Average Surgically induced Astigmatism

Table 15 shows that the average SIA in patients of group A (SICS) was -1.13±1.04D and -1.29 ± 0.95 in patients of group B (ECCE).

DISCUSSION

This study consisted of 120 patients who underwent cataract surgery at KLES Prabhakar Kore Hospital and MRC, Belgaum.

The patients were randomly divided into 2 groups depending on the type of the procedure.

Group A comprised 60 patients who underwent Manual small incision cataract surgery with posterior chamber intraocular lens implantation.

Group B comprised 60 patients who underwent conventional extracapsular cataract extraction with posterior chamber intraocular lens implantation.

In group A, the majority of the patients (47%) were in the 50-60 age group. In Group B, 43% were in the 61-70 age group (Table 1 and 2).

In both groups, about 60% of the patients were male. In group A, 55% patients had ATR astigmatism and 37% patients had WTR astigmatism. 8% patients had no preoperative astigmatism. In group B, 38% patients had WTR astigmatism while an equal number had ATR astigmatism. 24% patients had no preoperative astigmatism.

A study conducted by **Anders et al (1997)** showed that age and preoperative astigmatism were found to influence the induced astigmatism. [36]

Ninn Pederson (1997) confirmed that the most important predisposing factors for rapid changes in the postoperative astigmatism were large preoperative astigmatism, young age and low preoperative IOP. [37]

Surgically induced astigmatism refers to the difference between preoperative and postoperative values calculated by the vector method.

In group A (manual SICS with PCIOL implantation), 6% of the patients had no surgically induced astigmatism. 27% patients had SIA ranging from 0.25 – 0.5 D and another 27% in the range 0.75 – 1 D. 17% patients in the range 1.25 – 1.5 D (Table 11). Of these, most of the patients (67%) developed an ATR type of astigmatism with a mean of -1.08 D and 27% developed WTR astigmatism with a mean of -1.51 D (Table 13).

Azar D.T. et al (1997) proved in their study that sutureless group had the greatest proportion of patients with significant ATR astigmatic shift and the lowest proportion of patients with significant WTR astigmatic shift. They concluded that sutureless surgery resulted in a low percentage of WTR induced astigmatism postoperatively. [(38)]

Jakhanwal et al (2005) showed that the postoperative astigmatism in 70% of the patients who underwent manual SICS was less than or equal to 1.5D. [(3)]

In group B (conventional ECCE with PCIOL implantation), interrupted 10-0 nylon sutures were used to close the wound. As shown in Table 12, 3% of the patients had no surgically induced astigmatism. 24% patients had SIA ranging from 0.25 – 0.5 D and another 25% in the range 0.75 – 1 D. 18% patients in the range 1.25 – 1.5 D. Of these, most of the patients (62%) developed a WTR type of astigmatism with a mean of -1.31 D and 35% developed ATR astigmatism with a mean of -1.46 D.

In a study by **Gibson (1977)** in which the incidence of astigmatism after cataract surgery was evaluated, a comparison was made between interrupted and

continuous suturing with 10-0 nylon. It was observed that the incidence of WTR cylinder was more in interrupted suturing. [39]

Clayman and Jaffe (1975), in a series of 1557 eyes found that WTR astigmatism was associated with 10-0 nylon interrupted sutures while ATR astigmatism was associated with continuous suturing. [40]

In our study, the incision taken for SICS was a 6mm self sealing corneoscleral tunnel incision and a 6mm mid limbal incision in the ECCE group.

Liu Y and Li S (1995) studied the effect of the incision length on corneal astigmatism after IOL implantation. The surgically induced astigmatism at 1 month after operation 1.58 ± 1.07D in 6.5mm limbal incision group and 3.08 ± 1.11D in 11mm incision group. They concluded that reducing the incision size can minimise surgically induced astigmatism. [41]

In our study, the average surgically induced astigmatism in group A (SICS) was -1.13 ± 1.04D and -1.29 ± 0.95D in group B (ECCE) at 3 months postoperatively (table 15). This difference was not found to be statistically significant (unpaired t test= 0.895, DF=118, P=0.372).

This shows that by using a 6mm incision and placing only 3 interrupted 10-0 nylon sutures, the surgically induced astigmatism in extracapsular cataract extraction can be reduced and can be made comparable to that of small incision cataract surgery with a 6mm superior self sealing corneoscleral tunnel incision.

The slightly greater astigmatism in group B (ECCE) is due to the closure of the wound using 10-0 interrupted sutures. Interrupted sutures tend to produce wound compression. Wound compression results in a shortening of the vertical meridian of

the globe. This increases the curvature in the vertical meridian and causes a with the rule astigmatism. There is also some flattening of the horizontal meridian but to a lesser degree than the increased curvature in the vertical meridian. This explains the incidence of 80% WTR astigmatism in group B.

In group A (SICS), the lesser amount of surgically induced astigmatism is due the incision being sutureless and self sealing in nature.

CONCLUSION

CONCLUSION

The conclusions drawn from the present study were as follows:

- The average surgically induced astigmatism was less in small incision cataract surgery with posterior chamber intraocular lens implantation (Group A, 6mm self sealing corneoscleral tunnel incision) as compared to extracapsular cataract extraction with posterior chamber intraocular lens implantation (Group B, 6mm mid limbal incision sutured with 3 interrupted radial 10-0 nylon sutures) at 3 months postoperatively.

- The average surgically induced astigmatism in Group A was 1.13D with a standard deviation of 1.04D, while in group B it was 1.29D with a standard deviation of 0.95D.

- This difference in the average surgically induced astigmatism in the two groups was not found to be statistically significant. (P=0.372)

- After small incision cataract surgery with intraocular lens implantation, majority (90%) of the patients developed against the rule astigmatism postoperatively.

- After extracapsular cataract extraction with intraocular lens implantation, majority (80%) of the patients developed with the rule astigmatism postoperatively.

- Thus, our study demonstrated that by using a 6mm mid limbal incision and placing only 3 interrupted 10-0 nylon sutures in extracapsular cataract extraction, the surgically induced astigmatism can be reduced and can be made comparable to that of small incision cataract surgery with a 6mm superior self sealing corneoscleral tunnel incision.

SUMMARY

A one year randomised control trial was done to compare the postoperative corneal astigmatism induced by small incision cataract surgery with PCIOL implantation and extracapsular cataract extraction with PCIOL implantation in KLES Prabhakar Kore Hospital and MRC, Belgaum.

A total of 120 study subjects fulfilling the inclusion criteria were taken. In group A, 60 cases underwent SICS with PCIOL implantation where a 6mm self sealing corneoscleral tunnel incision was used. In group B, 60 cases underwent ECCE with PCIOL implantation where 6mm mid limbal incision taken was sutured with 3 interrupted radial 10-0 nylon sutures.

These patients were assigned to one of the 2 groups by computer generated blocks of two.

Keratometric readings were taken preoperatively as well as at 1-2 weeks, 6-8 weeks and 10-12 weeks postoperatively. The difference between the preoperative and postoperative keratometric readings were recorded by vector method.

In our study, the number of patients with a surgically induced astigmatism of <1.5D was 77% in group A and 70% in group B. The average surgically induced astigmatism at 3 months postoperatively in group A (SICS) was -1.13 ± 1.04D and -1.29 ± 0.95D in group B (ECCE). This difference was not found to be statistically significant (unpaired t test= 0.895, DF=118, P=0.372).

The slightly greater astigmatism in group B (ECCE) is due to the closure of the wound using 10-0 interrupted sutures. Interrupted sutures tend to produce wound

compression. Wound compression results in a shortening of the vertical meridian of the globe. This increases the curvature in the vertical meridian and causes a with the rule astigmatism. There is also some flattening of the horizontal meridian but to a lesser degree than the increased curvature in the vertical meridian. This explains the incidence of 80% WTR astigmatism in group B.

In group A (SICS), the lesser amount of surgically induced astigmatism is due the incision being sutureless and self sealing in nature.

Thus, our study demonstrated that by using a 6mm mid limbal incision and placing only 3 interrupted 10-0 nylon sutures in extracapsular cataract extraction, the surgically induced astigmatism can be reduced and can be made comparable to that of small incision cataract surgery with a 6mm superior self sealing corneoscleral tunnel incision.

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ANNNEXURE - I

DATA COLLECTION INSTRUMENT

PATIENT ID NO: | | | |

NAME: _____

AGE : | | | **yrs**

SEX: | | (1-Male; 2-Female)

IP NO: | | | | | | | |

OP NO: | | | | | | | |

DATE OF ADMISSION: | | | | | | | | | | |

DATE OF DISCHARGE: | | | | | | | | | | |

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

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

Chief complaints:

Diminution of vision ☐ Duration: _____ months/years

(1-Right eye; 2-Left eye)

History of present illness:

1. Diminution of vision ☐ Gradual ☐ Sudden

☐ Painless ☐ Painful

☐ For distance ☐ For near

2. Diplopia/polyopia ☐

3. Coloured haloes ☐

4. Black spots before the eyes ☐

5. Watering: ☐

6. Redness : ☐

7. H/o wearing spectacles: ☐ (1-Distance; 2-Near; 3-Both)

Duration:_____ months/years

Past history:

Diabetes: ☐ Duration: _____ months/years

Hypertension: ☐ Duration: _____ months/years

Any other medical disorder: _____

Personal history:

Smoking ☐ Duration:_____ months/years

Alcoholism ☐ Duration:_____ months/years

General physical examination:

Pallor ☐ Pulse: ____/minute

Oedema ☐ BP: _____ mm of Hg

Lymphadenopathy ☐ Temperature: _____°C

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:

	RIGHT EYE	LEFT EYE
1. **Visual acuity** Distant Vision Pinhole With Spectacles Near Vision(with spectacles)		
2. **Adnexa** (1-Normal; 2-Abnormal; if abnormal, specify:_____)	☐	☐
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)	☐	☐
7.**Iris** (1-Normal colour & pattern; 2-Abnormal)	☐	☐
8. **Pupil** (1- Round & regular; 2-Abnormal) Reaction: (1-Present; 2-Absent)	☐ ☐	☐ ☐
9. **Lens** (Cataract: 1-Nuclear; 2-Cortical; 3-Mixed; 4-Other)	☐	☐

Diagnosis: ☐

1-Senile immature cortical cataract

2- Senile mature cortical cataract

3- Senile nuclear cataract

4- Senile mixed cataract

5-Hypermature cataract (Morgagnian/Sclerotic)

Investigations:

1.Ocular

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

☐ LE

B. IOP: ☐ RE (1-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_1 (Dioptres)	Axis (Degrees)	K_2 (Dioptres)	Axis (Degrees)	Preoperative astigmatism(A) $A=K_1-K_2$	Axis(Degrees)

Operative procedure:

Surgery- ☐(1- ECCE with PCIOL implantation; 2-SICS with PCIOL implantation)

Date: ☐☐☐☐☐☐

1.Anaesthesia: ☐ (1-Peribulbar block; 2- Retrobulbar block)

2.Incision: ☐ (1-Limbal, 2-Scleral); Length: _____mm

Follow up Plan:

	1-2 weeks	6-8 weeks	10-12 weeks
1.**Conjunctiva** (1-Normal; 2-conjunctival congestion; 3-ciliary congestion)	☐	☐	☐
2.**Section/Suture site** (1-Edges opposed; 2-Edges gaping) **Sutures** (1-Intact; 2-Loose/Broken)	☐ ☐	☐ ☐	☐ ☐
2.**Cornea** (1-Clear; 2-Hazy/Descmets folds)	☐	☐	☐
3.**Anterior chamber** (1-Normal depth; 2-Shallow/Absent)	☐	☐	☐
4.**Pupil** Size Shape			
5.**Intraocular lens** (1-In situ; 2-decentered)	☐	☐	☐
6.**Vision**			

Postoperative Keratometry:

	K_1 (Dioptres)	Axis(Degrees)	K_2 (Dioptres)	Axis(Degrees)
1-2 wks				
6-8 wks				
10-12 wks				

Postoperative Astigmatism(B): _____ Dioptres (Axis= _____°)

Postoperative Day:_____

ANNEXURE - II

CONSENT FOR PARTICIPATION IN RESEARCH STUDY

Mr/Mrs/Ms_____

You are invited to participate in our research study titled "**Quantification of the corneal astigmatism following extracapsular cataract extraction vs small incision cataract surgery with intraocular lens implantation- a randomised controlled trial**" conducted by Dr. Arun Rajan, Post Graduate in M.S. Ophthalmology under the guidance of Dr. U.S. Dandavatimath 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.

Purpose of the Study:

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

Procedure Involved:

If you agree to enroll yourself in this study, I will ask your present, past and family 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 procedures, Extracapsular cataract extraction or 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 documented.

Risks and Benefits:

Rare complications of cataract surgery include endophthalmitis, 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.

Costs for participating in this research:

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.

Privacy and Confidentiality:

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.

Authorization to Publish Results:

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

Questions:

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

1.) Chief investigator, Dr. Arun Rajan, P.G., Department of Ophthalmology, JNMC, Belgaum. Ph No: 9916190615

2.) Dr. U.S. Dandavatimath, Professor, Guide, Department of Ophthalmology, JNMC, Belgaum. Ph: 9448181915

3.) 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.

Signature or the Left Thumb Print of Subject: _____

Investigators Name: Dr. Arun Rajan

Signature of Investigator: _____

Date: _____

Place: _____

ANNEXURE - III

FIGURES & PHOTOGRAPHS

Figure 1: Slit lamp photograph of senile immature cataract

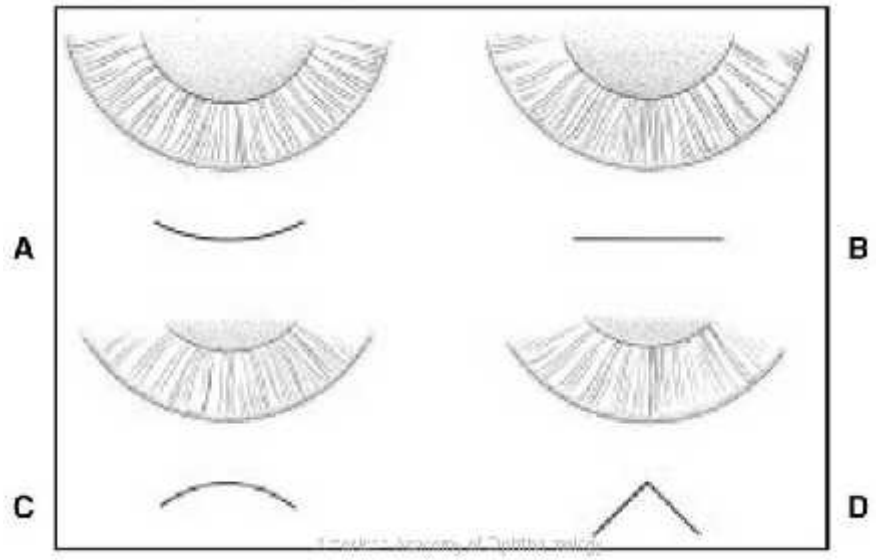


Figure 2: Different types of incisions in small incision cataract surgery

Photo 1: Keratometry with Bausch and Lomb keratometer

Photo 2: A scan Biometry

Photo 3: Tonometry with Schiotz tonometer

Photo 4: Testing for lacrimal system patency

Photo 5: Postoperative case of Extracapsular cataract extraction

Photo 6: Postoperative case of Small incision cataract surgery

ANNEXURE-IV

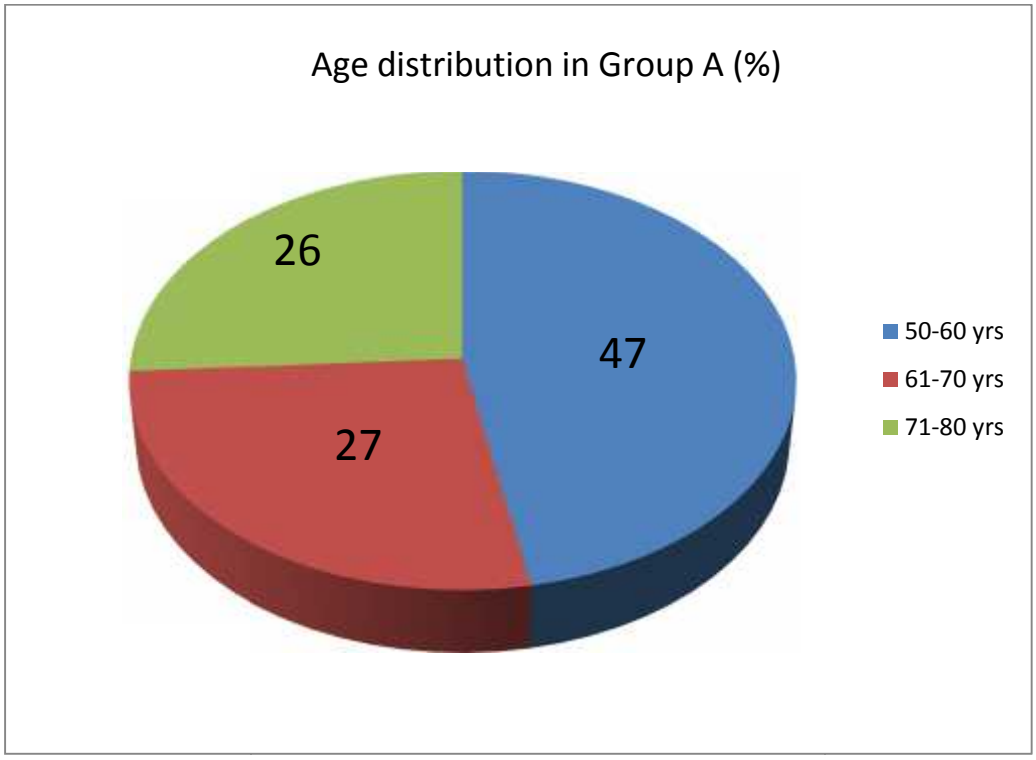
TABLES & GRAPHS

AGE DISTRIBUTION

Table 1

Group A

Age (yrs)	No. of patients	Percentage
50-60	28	47
61-70	19	27
71-80	13	26
TOTAL	**60**	**100**

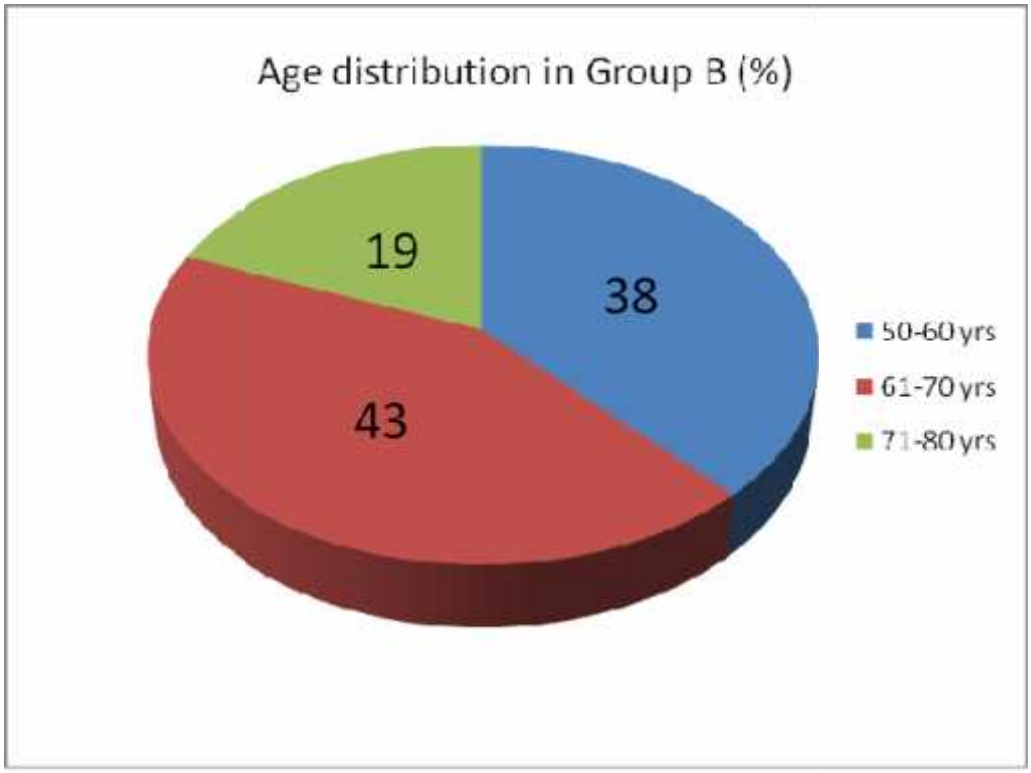


AGE DISTRIBUTION

Table 2

Group B

Age (yrs)	No. of patients	Percentage
50-60	23	38
61-70	26	43
71-80	11	19
TOTAL	**60**	**100**

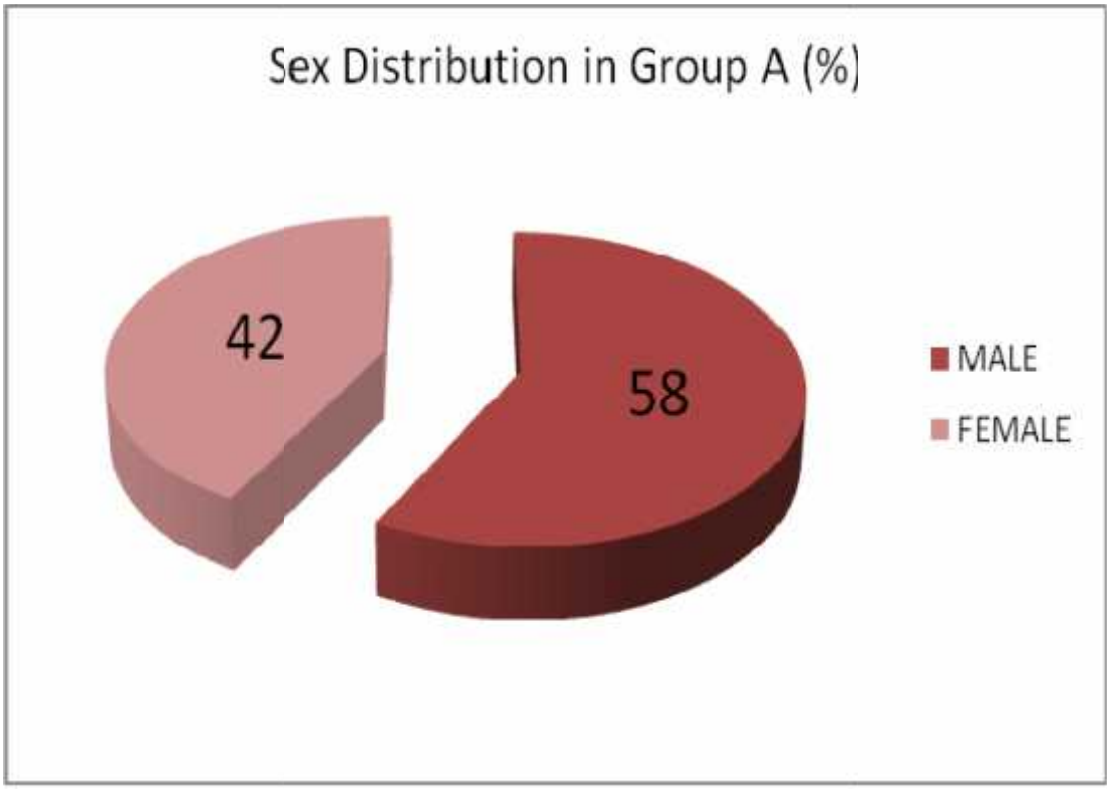


SEX DISTRIBUTION

Table 3

GROUP A

SEX	No. of patients	Percentage
MALE	35	58
FEMALE	25	42
TOTAL	**60**	**100**

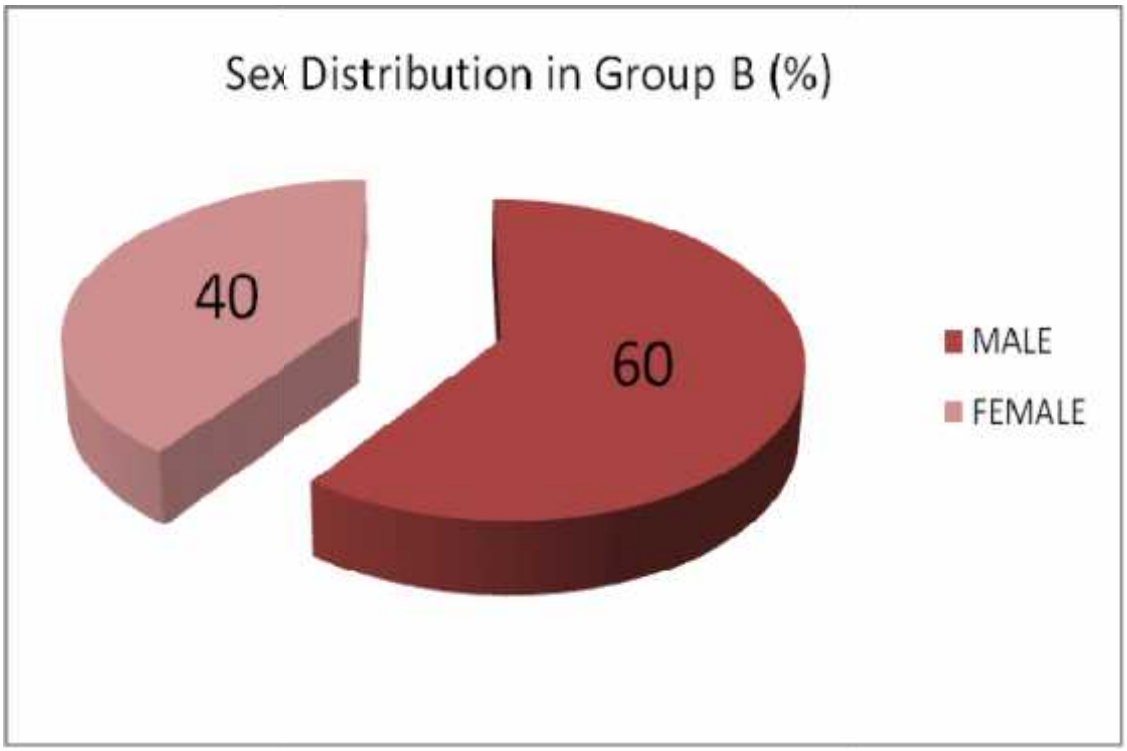


SEX DISTRIBUTION

Table 4

GROUP B

SEX	No. of patients	Percentage
MALE	36	60
FEMALE	24	40
TOTAL	**60**	**100**

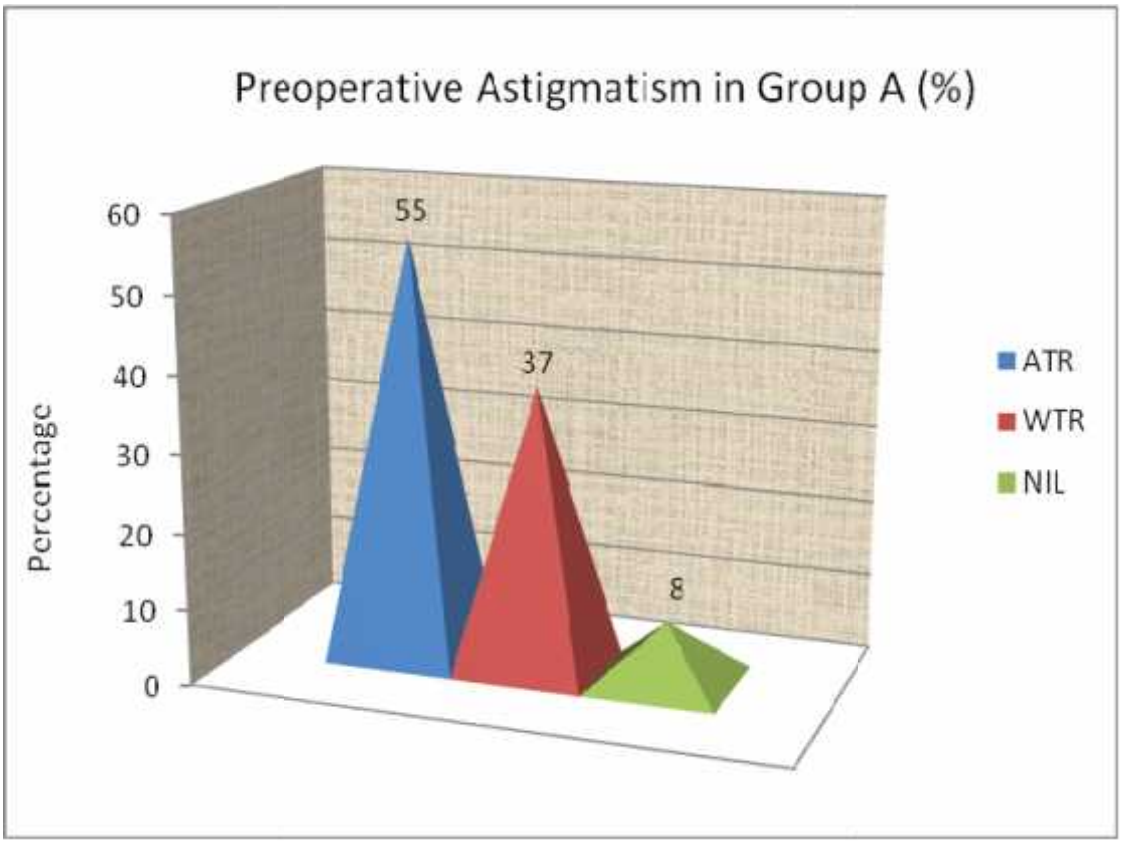


PREOPERATIVE ASTIGMATISM

Table 5

GROUP A

TYPE	No. of patients	Percentage	MEAN (D)
ATR	33	55	-0.85
WTR	22	37	-0.84
NIL	5	8	
TOTAL	**60**	**100**	

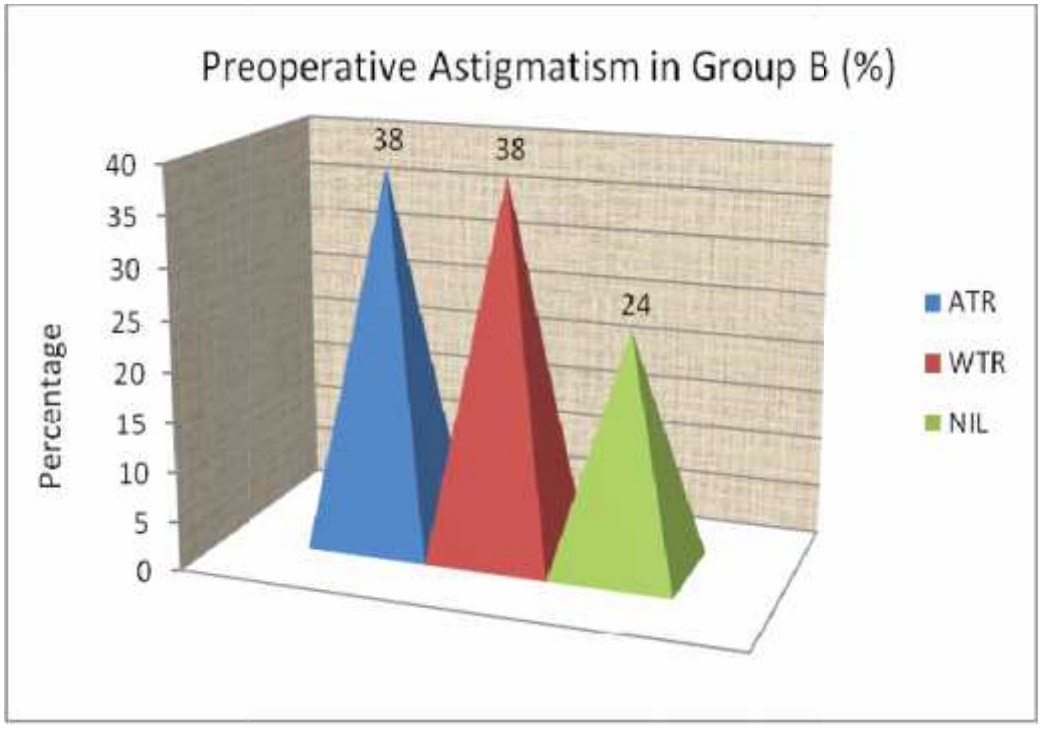


PREOPERATIVE ASTIGMATISM

Table 6

GROUP B

TYPE	No. of patients	Percentage	MEAN (D)
ATR	23	38	-1.08
WTR	23	38	-0.96
NIL	14	24	
TOTAL	**60**	**100**	

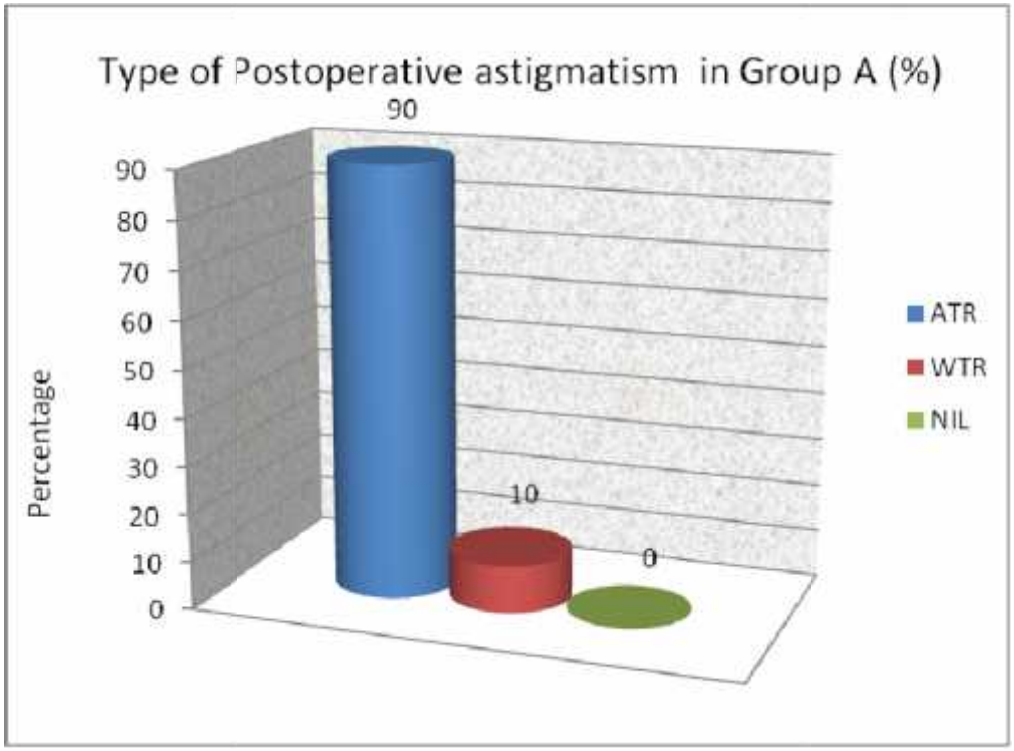


TYPE OF POSTOPERATIVE ASTIGMATISM

Table 7

GROUP A

TYPE	No. of patients	Percentage	MEAN (D)
ATR	54	90	-1.27
WTR	6	10	-0.67
NIL	0	0	
TOTAL	**60**	**100**	

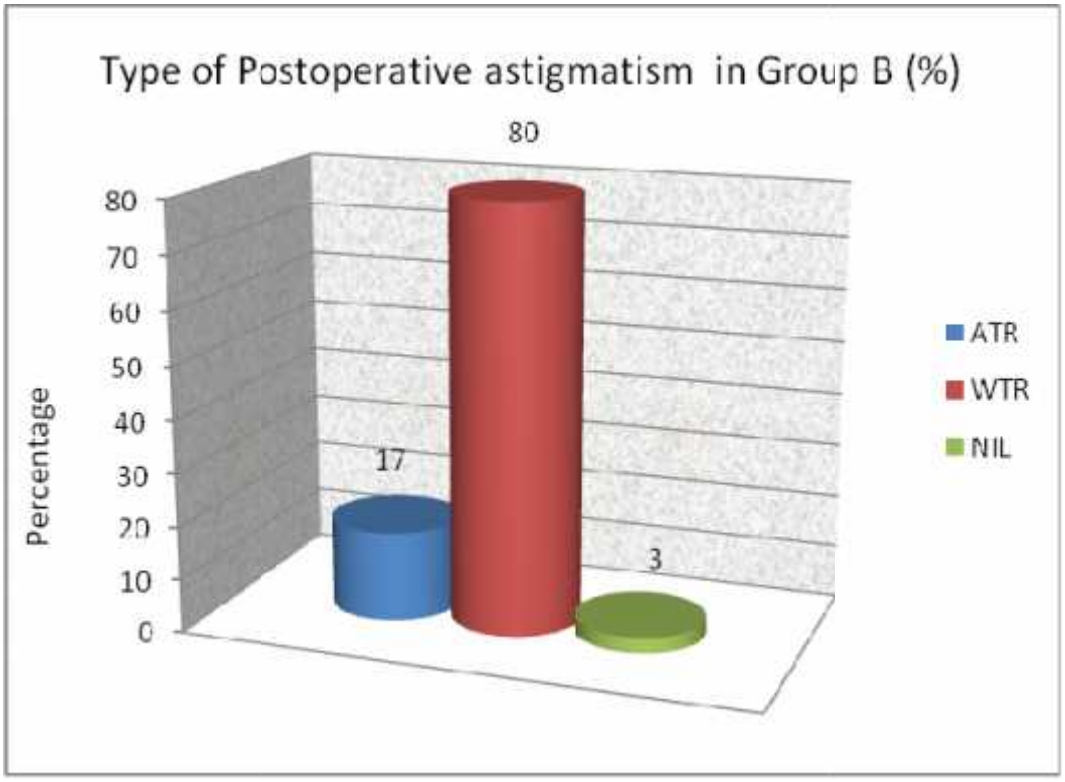


TYPE OF POSTOPERATIVE ASTIGMATISM

Table 8

GROUP B

TYPE	No. of patients	Percentage	MEAN (D)
ATR	10	17	-0.85
WTR	48	80	-1.51
NIL	2	3	
TOTAL	**60**	**100**	



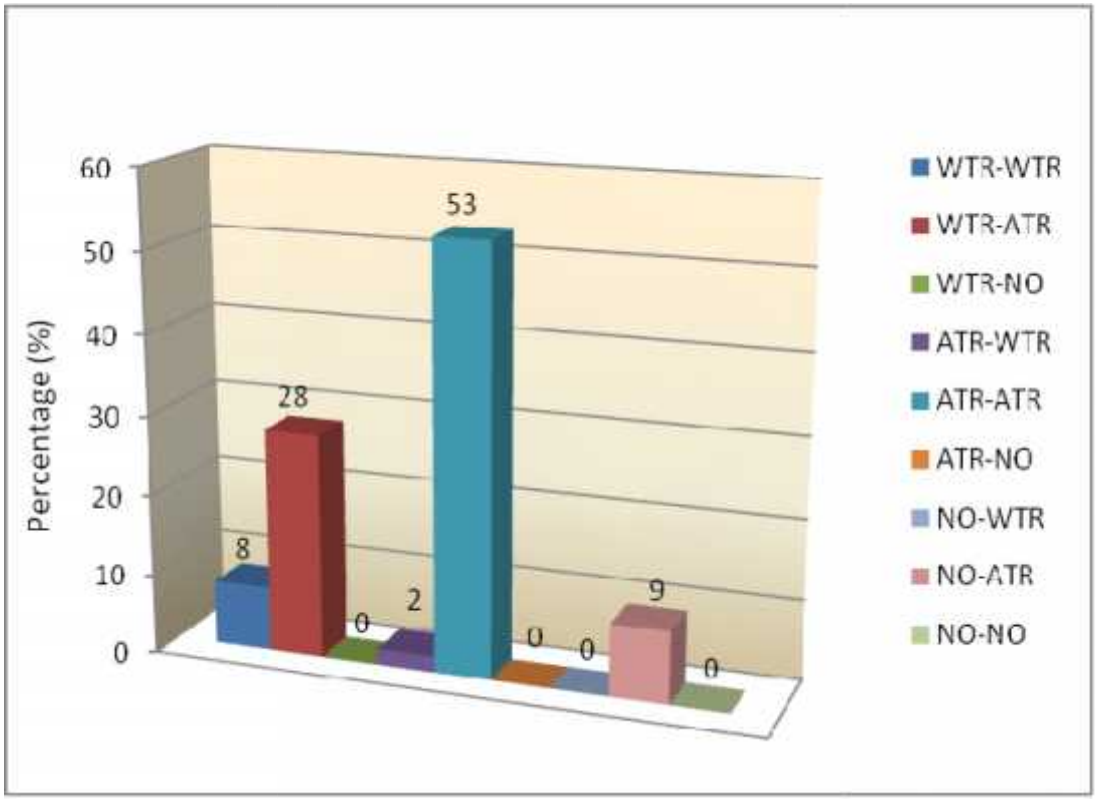
COMPARISON OF ASTIGMATIC CHANGE FROM PREOPERATIVE AND POSTOPERATIVE STATE

Table 9

GROUP A

CHANGE IN ASTIGMATISM	No. of patients	Percentage
WTR-WTR	5	8
WTR-ATR	17	28
WTR-NO	0	0
ATR-WTR	1	2
ATR-ATR	32	53
ATR-NO	0	0
NO-WTR	0	0
NO-ATR	5	9
NO-NO	0	0
TOTAL	**60**	**100**

COMPARISON OF ASTIGMATIC CHANGE FROM PREOPERATIVE AND POSTOPERATIVE STATE



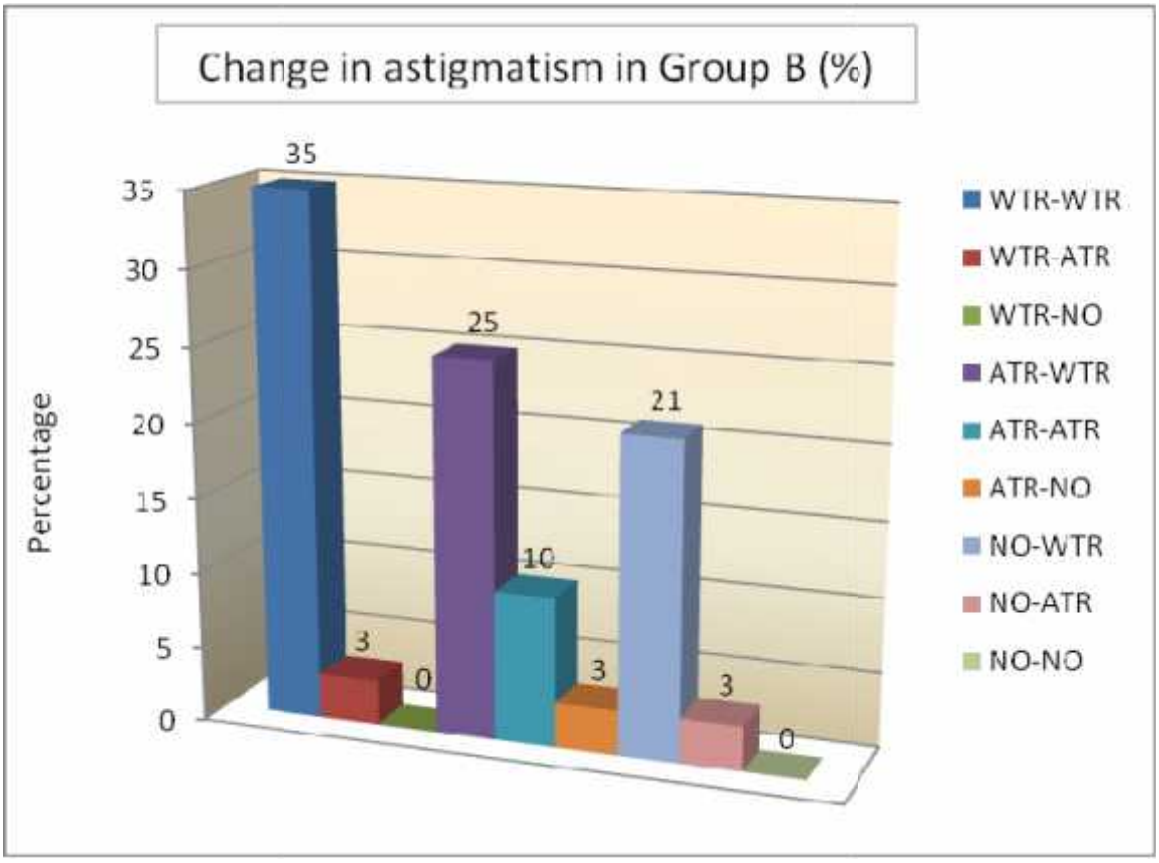
COMPARISON OF ASTIGMATIC CHANGE FROM PREOPERATIVE AND POSTOPERATIVE STATE

Table 10

GROUP B

CHANGE IN ASTIGMATISM	No. of patients	Percentage
WTR-WTR	21	35
WTR-ATR	2	3
WTR-NO	0	0
ATR-WTR	15	25
ATR-ATR	6	10
ATR-NO	2	3
NO-WTR	12	21
NNO-ATR	2	3
NO-NO	0	0
TOTAL	**60**	**100**

COMPARISON OF ASTIGMATIC CHANGE FROM PREOPERATIVE AND POSTOPERATIVE STATE



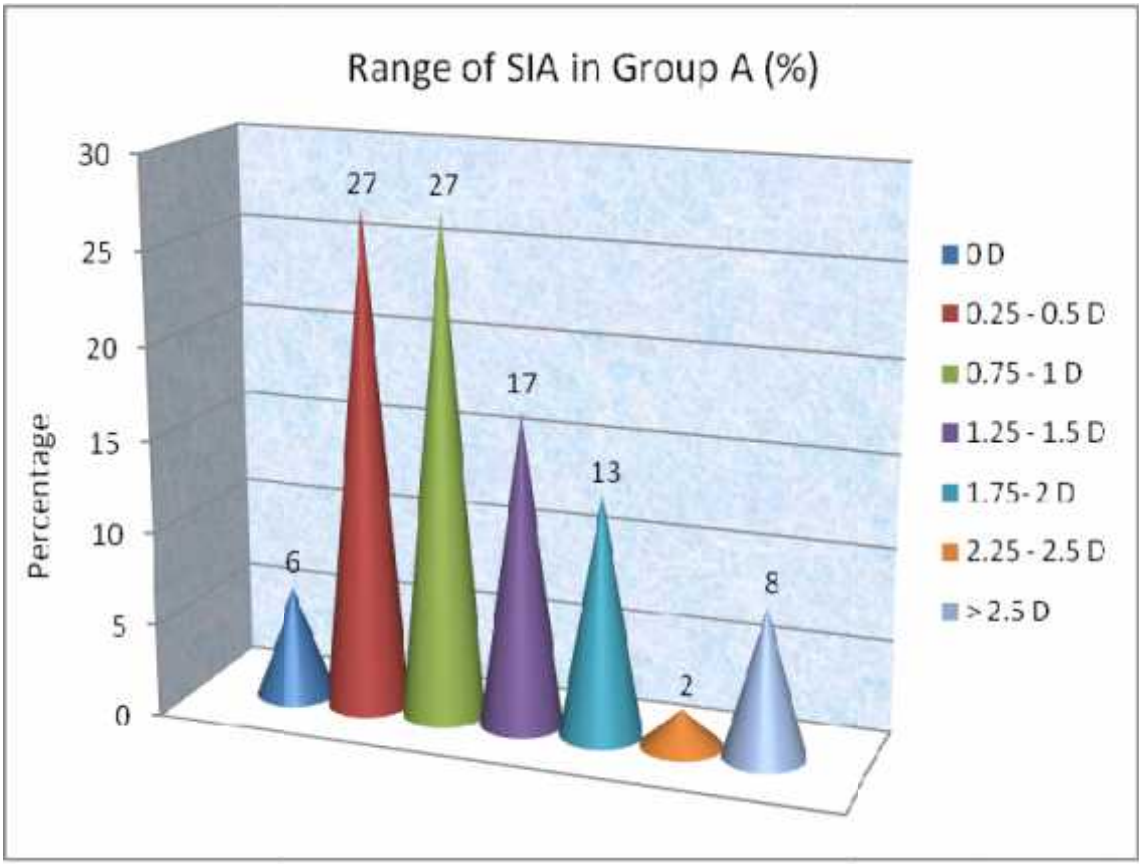
RANGE OF SURGICALLY INDUCED ASTIGMATISM

Table 11

GROUP A

RANGE	No. of patients	Percentage
0	4	6
0.25 - 0.5	16	27
0.75 - 1	16	27
1.25 - 1.5	10	17
1.75- 2	8	13
2.25 - 2.5	1	2
> 2.5	5	8
TOTAL	**60**	**100**

RANGE OF SURGICALLY INDUCED ASTIGMATISM



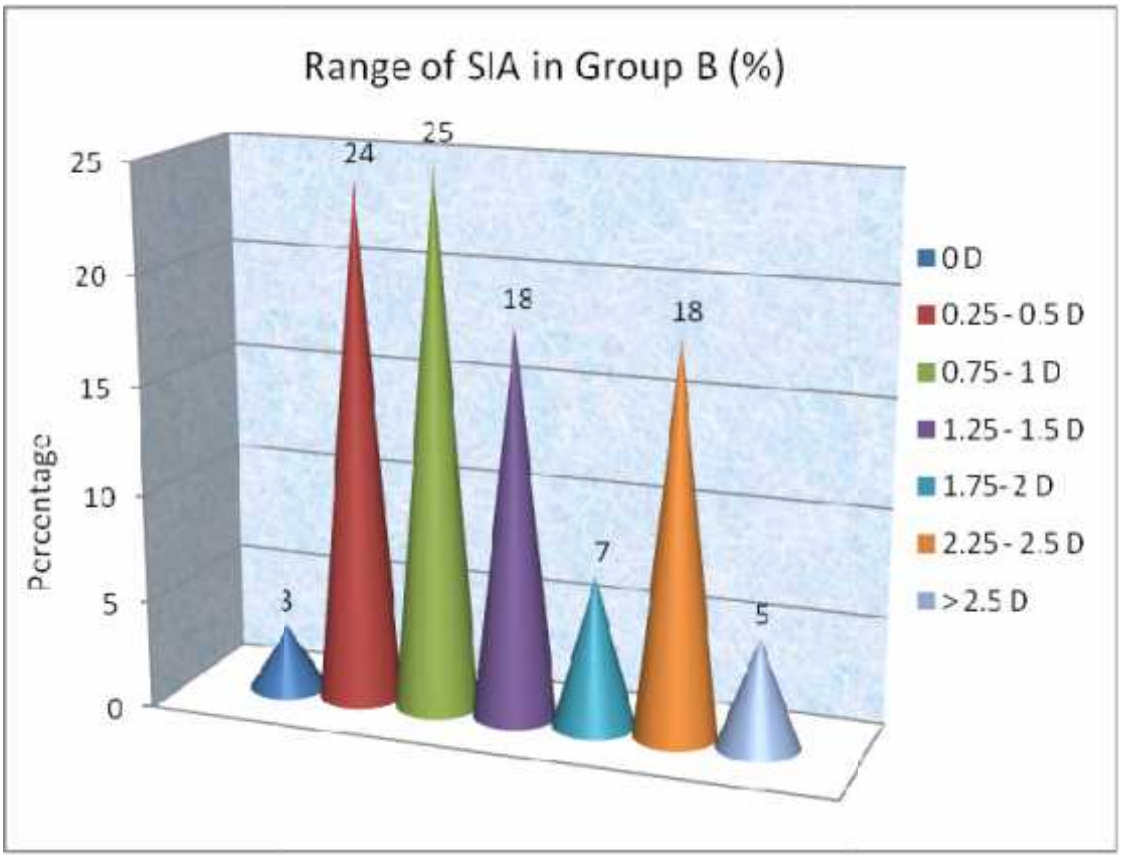
RANGE OF SURGICALLY INDUCED ASTIGMATISM

Table 12

GROUP B

RANGE	No. of patients	Percentage
0	2	3
0.25 - 0.5	14	24
0.75 - 1	15	25
1.25 - 1.5	11	18
1.75- 2	4	7
2.25 - 2.5	11	18
> 2.5	3	5
TOTAL	**60**	**100**

RANGE OF SURGICALLY INDUCED ASTIGMATISM

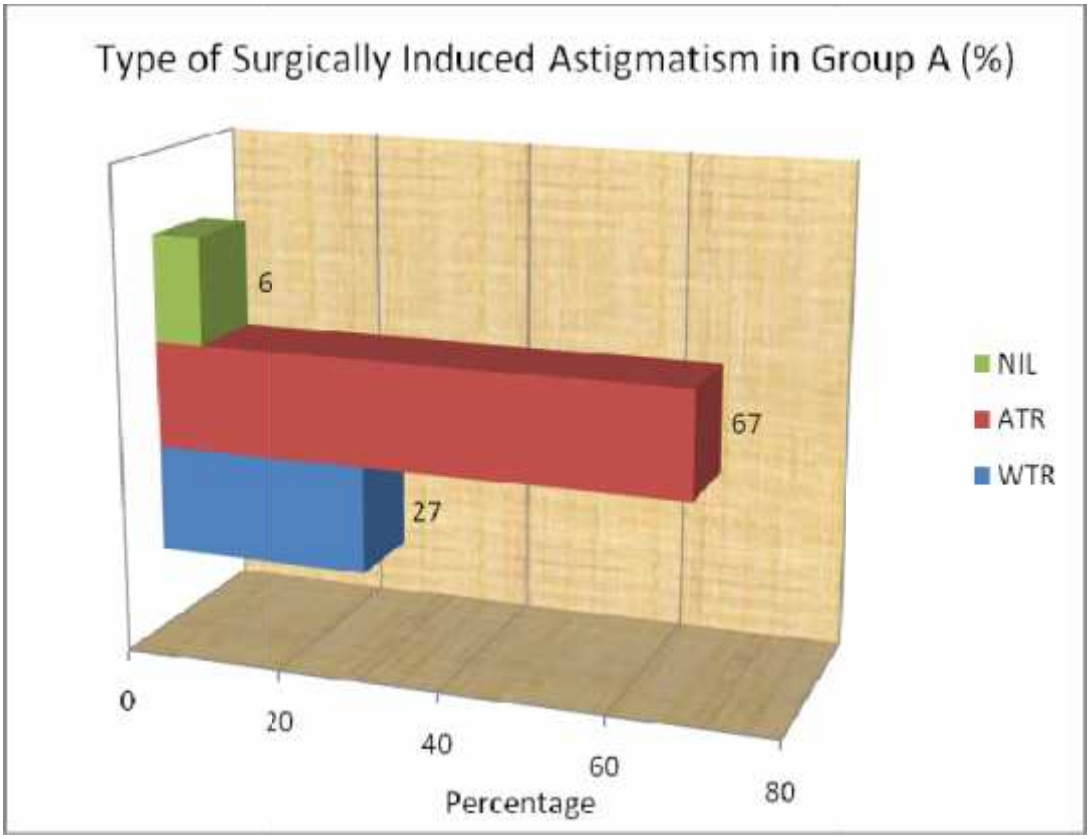


TYPE OF SURGICALLY INDUCED ASTIGMATISM

Table 13

GROUP A

TYPE	No. of patients	Percentage	MEAN (D)
WTR	16	27	-1.51
ATR	40	67	-1.08
NIL	4	6	
TOTAL	**60**	**100**	

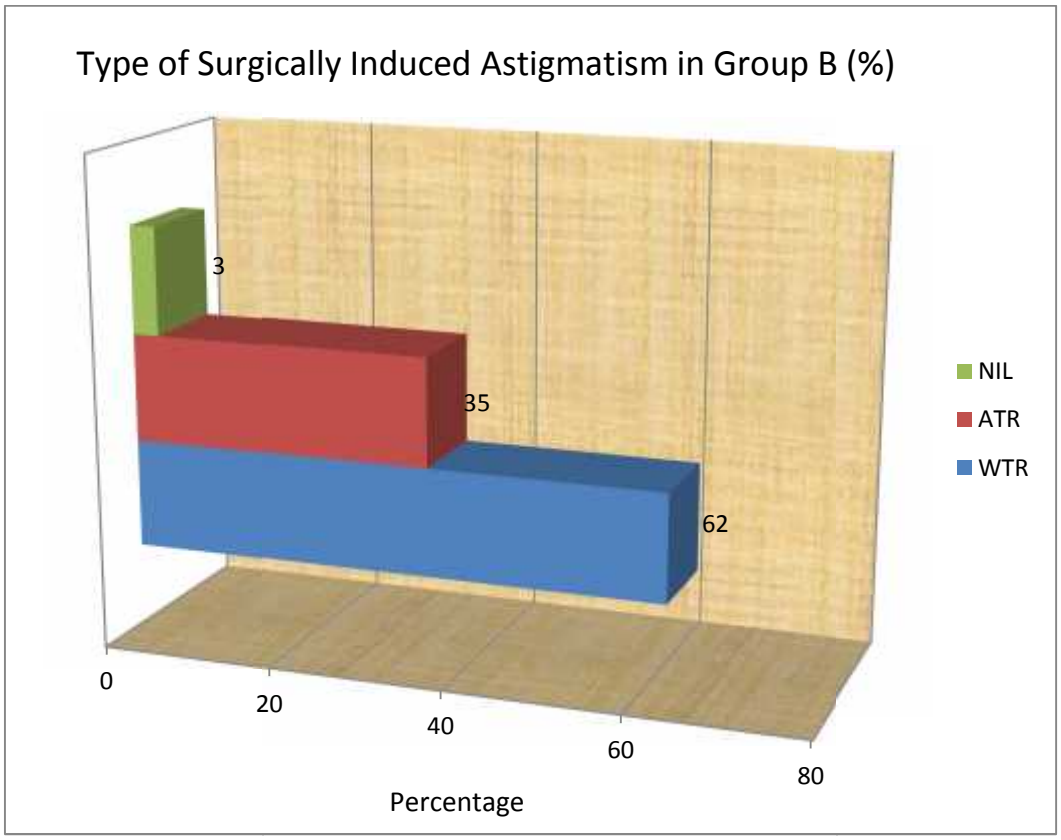


TYPE OF SURGICALLY INDUCED ASTIGMATISM

Table 14

GROUP B

TYPE	No. of patients	Percentage	MEAN (D)
WTR	37	62	-1.31
ATR	21	35	-1.46
NIL	2	3	
TOTAL	**60**	**100**	



COMPARISON OF AMOUNT OF SURGICALLY INDUCED ASTIGMATISM

Table 15

TYPE	GROUP A -SICS (D)	GROUP B -ECCE (D)
MEAN WTR	-1.51	-1.31
MEAN ATR	-1.08	-1.46
Average Surgically Induced Astigmatism	-1.13 ± 1.04	-1.29 ± 0.95

ABBREVIATIONS FOR THE MASTER CHART

M	Male
F	Female
LE	Left Eye
RE	Right Eye
ATR	Against the rule astigmatism
WTR	With the rule astigmatism

MASTER CHART: GROUP A

SL No	Age	Sex	Eye	IP No	Preoperative Keratometry readings			Preoperative Astigmatism			Postoperative Keratometry Readings				Postoperative Astigmatism			Surgically induced Astigmatism		
					K1	K2	Axis	Cyl	Axis	Type	Week	K1	K2	Axis	Cyl	Axis	Type	Cyl	Axis	Type
1	71	M	LE	263892	45.25	43.75	180/90	-1.5	90	ATR	12	44.25	42.25	180/90	-2	90	ATR	-0.5	90	ATR
2	57	M	RE	263186	43.5	43.75	180/90	-0.25	180	WTR	12	44	43.5	180/90	-0.5	90	ATR	-0.75	180	WTR
3	65	F	LE	266051	44.75	44.5	180/90	-0.25	90	ATR	12	44.5	44.25	180/90	-0.25	90	ATR	0		
4	70	F	RE	267080	43.5	44	180/90	-0.5	180	WTR	11	45	43	180/90	-2	90	ATR	-2.5	180	WTR
5	64	M	RE	272747	44.75	44.5	180/90	-0.25	90	ATR	11	44.5	44	180/90	-0.5	90	ATR	-0.25	90	ATR
6	54	F	LE	272749	44	44,25	180/90	-0.25	180	WTR	10	43	42	180/90	-0.5	90	ATR	-0.75	180	WTR
7	80	M	RE	272989	46	44	180/90	-2	90	ATR	11	46.5	41.5	180/90	-5	90	ATR	-3	90	ATR
8	55	F	LE	274493	46.5	46	180/90	-0.5	90	ATR	12	45.25	46	180/90	-0.75	180	WTR	-1.25	90	ATR
9	60	F	LE	214782	45.75	46	180/90	-0.25	180	WTR	10	45.25	46.25	180/90	-1	180	WTR	-0.75	180	WTR
10	52	M	LE	284117	45	46	180/90	-1	180	WTR	12	46	45.5	180/90	-0.5	90	ATR	-1.5	90	ATR
11	60	M	RE	283869	42	43	180/90	-1	180	WTR	10	40.25	42.25	180/90	-2	180	WTR	-1	180	WTR
12	67	F	RE	283029	43.5	43.25	180/90	-0.25	90	ATR	12	43.75	43	180/90	-0.75	90	ATR	-0.5	90	ATR
13	66	M	RE	282718	45.25	44.5	180/90	-0.75	90	ATR	11	45.25	43.75	180/90	-1.5	90	ATR	-0.75	90	ATR

SL No	Age	Sex	Eye	IP No	Preoperative Keratometry readings			Preoperative Astigmatism			Postoperative Keratometry Readings				Postoperative Astigmatism			Surgically induced Astigmatism		
					K1	K2	Axis	Cyl	Axis	Type	Week	K1	K2	Axis	Cyl	Axis	Type	Cyl	Axis	Type
14	60	M	RE	282743	43.5	41.75	180/90	-1.75	90	ATR	11	43.75	41.75	180/90	-2	90	ATR	-0.25	90	ATR
15	65	M	RE	282745	43.75	44	180/90	-0.75	180	WTR	11	44.25	43	180/90	-1.25	90	ATR	-2	180	WTR
16	55	M	RE	282049	43	42.5	180/90	-0.5	90	ATR	11	43.5	42.5	180/90	-1	90	ATR	-0.5	90	ATR
17	56	F	RE	281730	46.5	48.25	180/90	-1.75	180	WTR	11	46.5	48	180/90	-1.5	180	WTR	-0.25	180	WTR
18	46	M	LE	281768	43.5	43.75	180/90	-0.25	180	WTR	11	44.5	43.5	180/90	-1	90	ATR	-1.25	90	ATR
19	70	M	LE	281788	46	44.5	180/90	-1.5	90	ATR	11	45	43.5	180/90	-1.5	90	ATR	0		
20	58	M	RE	280749	39.25	39	180/90	-0.25	90	ATR	12	40	39	180/90	-1	90	ATR	-0.75	90	ATR
21	80	F	LE	280826	44	43.25	180/90	-0.75	90	ATR	12	44.5	43	180/90	-1.5	90	ATR	-0.75	90	ATR
22	65	F	LE	279849	43.25	43	180/90	-0.25	90	ATR	11	44	43	180/90	-1	90	ATR	-0.75	90	ATR
23	56	F	LE	279845	48.5	48.25	180/90	-0.25	90	ATR	10	48.5	47.5	180/90	-1	90	ATR	-0.75	90	ATR
24	71	M	LE	279815	41.75	41.5	180/90	-0.25	90	ATR	10	42	40	180/90	-2	90	ATR	-1.75	90	ATR
25	65	M	RE	279811	42	41	180/90	-1	90	ATR	12	42	40.75	180/90	-1.25	90	ATR	-0.25	90	ATR
26	58	F	LE	278937	39.75	43.75	180/90	-4	180	WTR	10	44.75	44.25	180/90	-0.25	90	ATR	-4.25	90	ATR
27	79	M	LE	278917	44.25	43.75	180/90	-0.5	90	ATR	11	44.25	43	180/90	-1.25	90	ATR	-0.75	90	ATR
28	70	F	RE	278969	46.5	47.25	180/90	-0.75	180	WTR	11	46.75	45.75	180/90	-1	90	ATR	-1.75	90	ATR

SL No	Age	Sex	Eye	IP No	Preoperative Keratometry readings			Preoperative Astigmatism			Postoperative Keratometry Readings				Postoperative Astigmatism			Surgically induced Astigmatism		
					K1	K2	Axis	Cyl	Axis	Type	Week	K1	K2	Axis	Cyl	Axis	Type	Cyl	Axis	Type
29	74	M	LE	278923	42.75	44.75	180/90	-2	180	WTR	10	45	42.75	180/90	-2.25	90	ATR	-4.25	180	WTR
30	50	F	RE	278951	44.5	45	180/90	-0.5	180	WTR	12	45	43.75	180/90	-1.25	90	ATR	-1.75	180	WTR
31	55	F	LE	277970	42.25	42.25	180/90	0			11	44	42.25	180/90	-1.25	90	ATR	-1.25	90	ATR
32	59	M	RE	277976	39.75	40	180/90	-0.25	180	WTR	12	40.75	39.5	180/90	-1.25	90	ATR	-1.5	180	WTR
33	60	M	LE	278324	43.5	44.25	180/90	-0.75	180	WTR	11	45	44	180/90	-1	90	ATR	-1.75	180	WTR
34	80	M	RE	277099	47	46	180/90	-1	90	ATR	11	46.5	43.75	180/90	-2.75	90	ATR	-1.75	90	ATR
35	68	M	LE	277045	41.75	41	180/90	-0.75	90	ATR	10	42.5	42	180/90	-0.5	90	ATR	-0.25	90	ATR
36	70	M	RE	276476	47.75	46.75	180/90	-0.5	90	ATR	11	47.5	46.5	180/90	-1	90	ATR	-0.5	90	ATR
37	59	M	RE	276166	44.25	44.5	180/90	-0.25	180	WTR	12	44.5	44.75	180/90	-0.25	180	WTR	0		
38	80	M	LE	276615	42.25	42	180/90	-0.25	90	ATR	11	45.5	44.5	180/90	-1	90	ATR	-0.75	90	ATR
39	50	F	LE	275595	41	42	180/90	-1	180	WTR	11	40.25	41.75	180/90	1.5	180	WTR	-0.5	180	WTR
40	60	M	RE	275612	44	42	180/90	-2	90	ATR	12	44.25	43.25	180/90	-1	90	ATR	-1	90	ATR
41	74	M	RE	275331	47.25	46	180/90	-1.25	90	ATR	10	46.5	46	180/90	-0.5	90	ATR	-0.75	90	ATR
42	70	F	LE	275203	40.75	41.25	180/90	-0.5	180	WTR	11	42.5	41.5	180/90	-1	90	ATR	-1.5	180	WTR
43	70	F	RE	275299	42.25	42	180/90	-0.25	90	ATR	11	47	44	180/90	-3	90	ATR	-2.75	90	ATR

SL No	Age	Sex	Eye	IP No	Preoperative Keratometry readings			Preoperative Astigmatism			Postoperative Keratometry Readings				Postoperative Astigmatism			Surgically induced Astigmatism		
					K1	K2	Axis	Cyl	Axis	Type	Week	K1	K2	Axis	Cyl	Axis	Type	Cyl	Axis	Type
44	63	F	LE	275327	43	43.5	180/90	-0.5	180	WTR	12	43.75	42.25	180/90	-1.5	90	ATR	-2	180	WTR
45	70	M	RE	284451	46	44.5	180/90	-1.5	90	ATR	12	45.75	44	180/90	-1.75	90	ATR	-0.25	90	ATR
46	72	F	RE	285272	45.75	44.25	180/90	-1	90	ATR	12	46	44	180/90	-2	90	ATR	-1	90	ATR
47	65	F	RE	285251	42.25	40.5	180/90	-2	90	ATR	11	42.25	40	180/90	-2.25	90	ATR	-0.25	90	ATR
48	65	F	LE	285270	42	41.25	180/90	-0.75	90	ATR	12	42	41	180/90	-1	90	ATR	-0.25	90	ATR
49	60	F	RE	285252	45.5	46	180/90	-0.5	180	WTR	12	46.25	45.5	180/90	-0.75	90	ATR	-1.25	180	WTR
50	59	M	RE	285257	42.75	42.75	180/90	0			12	43	42.25	180/90	-0.75	90	ATR	-0.75	90	ATR
51	60	M	LE	285258	41.75	41	180/90	-0.75	90	ATR	12	42	40.75	180/90	-1.25	90	ATR	-0.5	90	ATR
52	58	M	LE	286198	43.5	43.5	180/90	0			10	43.75	43.25	180/90	-0.5	90	ATR	-0.5	90	ATR
53	65	F	RE	285816	41.75	40	180/90	-1.75	90	ATR	12	41.75	40	180/90	-1.75	90	ATR	0		
54	60	F	LE	287442	42.75	42	180/90	-0.75	90	ATR	12	43	42.25	180/90	-1.75	90	ATR	-1	90	ATR
55	54	M	RE	287750	43.25	43.25	180/90	0			10	43.75	43	180/90	-0.75	90	ATR	-0.75	90	ATR
56	65	M	LE	287848	44	44.5	180/90	-0.5	180	WTR	11	45	43.75	180/90	-1.25	90	ATR	-1.75	180	WTR
57	61	M	LE	287769	43.75	44.75	180/90	-1	180	WTR	12	44.75	44	180/90	-0.75	90	ATR	-1.75	90	ATR
58	67	M	LE	287789	42	42	180/90	0			10	42.5	41.75	180/90	-0.75	90	ATR	-0.75	90	ATR

SL No	Age	Sex	Eye	IP No	Preoperative Keratometry readings			Preoperative Astigmatism			Postoperative Keratometry Readings				Postoperative Astigmatism			Surgically induced Astigmatism		
					K1	K2	Axis	Cyl	Axis	Type	Week	K1	K2	Axis	Cyl	Axis	Type	Cyl	Axis	Type
59	57	M	RE	288810	43.25	42.75	180/90	-0.5	90	ATR	11	43.5	42.5	180/90	-1	90	ATR	-5	90	ATR
60	50	F	LE	288824	42.25	41.75	180/90	-0.5	90	ATR	11	42.75	42	180/90	-0.75	90	ATR	-0.25	90	ATR

MASTER CHART: GROUP B

SL No	Age	Sex	Eye	IP No	Preoperative Keratometry readings			Preoperative Astigmatism			Postoperative Keratometry Readings				Postoperative Astigmatism			Surgically induced Astigmatism		
					K1	K2	Axis	Cyl	Axis	Type	Week	K1	K2	Axis	Cyl	Axis	Type	Cyl	Axis	Type
1	60	F	LE	257117	46.5	44.5	180/90	-2	90	ATR	12	44.5	43	180/90	-1.5	90	ATR	-0.5	90	ATR
2	70	M	RE	283856	41	41	180/90	0			12	41.25	40.75	180/90	-0.5	90	ATR	-0.5	90	ATR
3	55	F	RE	283713	44.5	45.25	180/90	-0.75	180	WTR	12	45.25	45	180/90	-0.25	90	ATR	-1	90	ATR
4	68	M	LE	283032	46.5	46	180/90	-0.5	90	ATR	10	45	46.75	180/90	-1.75	180	WTR	.2.25	90	ATR
5	70	F	LE	283037	42	44.5	180/90	-2.5	180	WTR	12	43	45	180/90	-2	180	WTR	-0.5	180	WTR
6	75	M	LE	282742	43.25	42.25	180/90	-1	90	ATR	11	42.75	40.75	180/90	-2	90	ATR	-1	90	ATR
7	68	M	RE	281142	42	40	180/90	-2	90	ATR	10	39.5	42.75	180/90	-3.25	180	WTR	-5.25	90	ATR
8	60	M	LE	281102	47.5	48	180/90	-0.5	180	WTR	11	46	47	180/90	-1	180	WTR	-0.5	180	WTR
9	70	M	LE	278936	46.5	46	180/90	-0.5	90	ATR	11	46	46.5	180/90	-0.5	180	WTR	-1	90	ATR
10	68	M	RE	278319	40.75	41	180/90	-0.75	180	WTR	12	41	40.75	180/90	-0.25	90	ATR	-1	90	ATR
11	78	F	RE	278325	47.75	46	180/90	-1.75	90	ATR	11	42	43	180/90	-1	180	WTR	-2.75	180	WTR
12	52	F	RE	272700	43	45	180/90	-2	180	WTR	12	42	44	180/90	-2	180	WTR	0		
13	74	M	RE	276208	42.5	42.75	180/90	-0.25	180	WTR	11	41	42	180/90	-1	180	WTR	-0.75	180	WTR

SL No	Age	Sex	Eye	IP No	Preoperative Keratometry readings			Preoperative Astigmatism			Postoperative Keratometry Readings				Postoperative Astigmatism			Surgically induced Astigmatism		
					K1	K2	Axis	Cyl	Axis	Type	Week	K1	K2	Axis	Cyl	Axis	Type	Cyl	Axis	Type
14	65	M	RE	276240	42.25	45	180/90	-2.75	180	WTR	10	42	47	180/90	-5	180	WTR	-2.25	180	WTR
15	70	F	RE	284436	47	45	180/90	-2	90	ATR	12	46.5	46.25	180/90	-0.25	90	ATR	-1.75	90	ATR
16	54	M	LE	287738	45	46	180/90	-1	180	WTR	10	44.75	46.75	180/90	-2	180	WTR	-1	180	WTR
17	60	M	RE	288157	46	47	180/90	-1	180	WTR	10	45.5	47	180/90	-1.5	180	WTR	-0.5	180	WTR
18	80	M	RE	288127	47	46	180/90	-1	90	ATR	11	44.25	45.75	180/90	-1.5	180	WTR	-2.5	90	ATR
19	55	F	RE	289919	45.25	47.5	180/90	-2.25	180	WTR	10	46	46.75	180/90	-0.75	180	WTR	-1.5	180	WTR
20	51	M	RE	289168	45.5	45	180/90	-0.5	90	ATR	12	46.25	45.25	180/90	-1	90	ATR	-0.5	90	ATR
21	50	F	LE	290206	48	48	180/90	0			12	48.25	48.5	180/90	-0.25	180	WTR	-0.25	180	WTR
22	55	F	RE	290224	44.5	44.5	180/90	0			12	45	45.5	180/90	-0.5	180	WTR	-0.5	180	WTR
23	65	M	RE	290746	42.25	42.5	180/90	-0.25	180	WTR	12	43	43.25	180/90	-0.25	180	WTR	0		
24	70	F	RE	292257	44.25	45.25	180/90	-1	180	WTR	12	44	46	180/90	-2	180	WTR	-1	180	WTR
25	68	M	LE	292249	43	43	180/90	0			12	43	42.25	180/90	-0.75	90	ATR	-0.75	90	ATR
26	50	M	RE	292294	43.25	42.5	180/90	-0.75	90	ATR	12	42.5	44.25	180/90	-1.75	180	WTR	-2.5	90	ATR
27	75	M	LE	293282	45.5	45.5	180/90	0			11	45.75	46.25	180/90	-0.5	180	WTR	-0.5	180	WTR
28	60	F	RE	295769	44.5	43.5	180/90	-1	90	ATR	12	44.75	45	180/90	-0.25	180	WTR	-1.25	180	WTR

SL No	Age	Sex	Eye	IP No	Preoperative Keratometry readings			Preoperative Astigmatism			Postoperative Keratometry Readings				Postoperative Astigmatism			Surgically induced Astigmatism		
					K1	K2	Axis	Cyl	Axis	Type	Week	K1	K2	Axis	Cyl	Axis	Type	Cyl	Axis	Type
29	65	M	RE	294905	44	44	180/90	0			12	44.5	45.75	180/90	-1.25	180	WTR	-1.25	180	WTR
30	60	M	RE	294812	42	42.5	180/90	-0.5	180	WTR	12	42.5	45.25	180/90	-2.75	180	WTR	-2.25	180	WTR
31	60	M	RE	295800	46	47	180/90	-1	180	WTR	12	45.75	48	180/90	-2.25	180	WTR	-1.25	180	WTR
32	65	F	RE	297638	44.5	44.25	180/90	-0.25	90	ATR	11	43.25	45.25	180/90	-2	180	WTR	-2.25	90	ATR
33	70	F	LE	297978	45.25	45.5	180/90	-0.25	180	WTR	12	43.5	46.75	180/90	-3.25	180	WTR	-2	180	WTR
34	65	F	LE	297977	45.5	45.25	180/90	-0.25	90	ATR	10	44.25	46.25	180/90	-2	180	WTR	-2.25	90	ATR
35	60	M	RE	298577	46	46	180/90	0			10	45.25	47	180/90	-1.75	180	WTR	-1.75	180	WTR
36	58	M	RE	298575	46	46	180/90	0			12	45.25	47.5	180/90	-2.25	180	WTR	-2.25	180	WTR
37	61	M	LE	299624	40	40.25	180/90	-0.25	180	WTR	11	38.25	42.25	180/90	-4	180	WTR	-3.75	180	WTR
38	69	M	RE	300187	44	44.25	180/90	-0.25	180	WTR	11	43.75	46.25	180/90	-2.5	180	WTR	-2.25	180	WTR
39	75	M	RE	302549	42	41	180/90	-1	90	ATR	12	43	43.25	180/90	-0.25	180	WTR	-1.25	180	WTR
40	72	M	LE	302470	44.5	43	180/90	-1.5	90	ATR	12	45.25	45.5	180/90	-0.25	180	WTR	-1.75	180	WTR
41	58	M	RE	302475	43.75	44.75	180/90	-1	180	WTR	12	44.25	47.5	180/90	-3.25	180	WTR	-2.25	180	WTR
42	65	M	RE	302560	43	43	180/90	0			12	44	46.25	180/90	-2.25	180	WTR	-2.25	180	WTR
43	64	F	LE	302473	42	42	180/90	0			12	43.25	44.75	180/90	-1.5	180	WTR	-1.5	180	WTR

SL No	Age	Sex	Eye	IP No	Preoperative Keratometry readings			Preoperative Astigmatism			Postoperative Keratometry Readings				Postoperative Astigmatism			Surgically induced Astigmatism		
					K1	K2	Axis	Cyl	Axis	Type	Week	K1	K2	Axis	Cyl	Axis	Type	Cyl	Axis	Type
44	80	M	RE	304787	41	41	180/90	0			12	41.25	42	180/90	-0.75	180	WTR	-0.75	180	WTR
45	65	F	LE	304796	44.5	45.25	180/90	-0.75	180	WTR	12	45	47	180/90	-2	180	WTR	-1.25	180	WTR
46	60	M	RE	305048	44.5	44.5	180/90	0			12	44.75	46.25	180/90	-1.5	180	WTR	-1.5	180	WTR
47	50	F	LE	306847	47.25	45.25	180/90	-2	90	ATR	12	47.5	46.5	180/90	-1	90	ATR	-1	90	ATR
48	60	M	RE	308804	44	44	180/90	0			12	45	46	180/90	-1	180	WTR	-1	180	WTR
49	65	F	RE	307415	45	45	180/90	0			12	45.5	46	180/90	-0.5	180	WTR	-0.5	180	WTR
50	65	M	RE	307418	42.5	42.75	180/90	-0.25	180	WTR	12	43	43.5	180/90	-0.5	180	WTR	-0.25	180	WTR
51	80	F	RE	315685	41.5	40.5	180/90	-1	90	ATR	10	41.5	42	180/90	-0.5	180	WTR	-1.5	180	WTR
52	50	M	LE	315701	46	46.75	180/90	-0.75	180	WTR	10	47.25	47.75	180/90	-0.5	180	WTR	-0.25	180	WTR
53	68	M	RE	316123	43.5	44.5	180/90	-1	180	WTR	12	44.25	45.5	180/90	-1.25	180	WTR	-0.25	180	WTR
54	62	F	LE	316508	42.5	43.5	180/90	-1	180	WTR	12	43.25	44.75	180/90	-1.5	180	WTR	-0.5	180	WTR
55	62	F	RE	316819	45.5	45.25	180/90	-0.25	90	ATR	12	45.5	46.25	180/90	-0.75	180	WTR	-1	90	ATR
56	60	F	LE	318341	45	44	180/90	-1	90	ATR	12	46	46	180/90	0			-1	90	ATR
57	60	F	RE	318347	46	45	180/90	-1	90	ATR	12	46.25	47	180/90	-0.75	180	WTR	-1.75	180	WTR
58	80	F	LE	318654	44.75	44.5	180/90	-0.25	90	ATR	12	45	45.75	180/90	-0.75	180	WTR	-1	90	ATR

SL No	Age	Sex	Eye	IP No	Preoperative Keratometry readings			Preoperative Astigmatism			Postoperative Keratometry Readings				Postoperative Astigmatism			Surgically induced Astigmatism		
					K1	K2	Axis	Cyl	Axis	Type	Week	K1	K2	Axis	Cyl	Axis	Type	Cyl	Axis	Type
59	80	M	LE	319270	45.5	43	180/90	-2.5	90	ATR	12	45.5	44.5	180/90	-1	90	ATR	-1.5	90	ATR
60	70	M	RE	319278	44	43	180/90	-1	90	ATR	12	44	44	180/90	0			-1	90	ATR