EVALUATION OF ASTIGMATISM FOLLOWING CATARACT SURGICAL PROCEDURES

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To my mother who encouraged me since infancy
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ABSTRACT

This is a clinical prospective comparative study comparing phaco with large incision extracapsular cataract extraction with posterior chamber intraocular lens regarding postoperative astigmatism. It aimed to compare the prevalence of astigmatism and its relation to the wound size, number of sutures, and mode of suturing following each type of surgery. Other causes of postoperative astigmatism were explored.

Methods: The study was done in Makka Eye Complex in the period 1/6/2004 to 31/5/2005. A total of 200 patients who completed the period of follow-up were evaluated regarding the postoperative astigmatism.

Patients were interviewed for the present and past ocular history. Visual acuity was obtained pre- and postoperatively. Both anterior and posterior segments were examined for every patient using slit-lamp biomicroscopy and direct ophthalmoscope. Refraction was examined at the 4th and 8th postoperative weeks. Pre- and postoperative keratometry was checked and surgical induced astigmatism was calculated using simple subtraction method. Sutures were removed from patients whom were
suspected to benefit from removal of sutures. Refraction and keratometry were examined 4 weeks after removal of sutures. Other causes were explored and results were compared between the two types of surgery.

**Results:** Hundred patients had phaco surgery and same number had large incision extracapsular cataract extraction. Ninety-seven patients (97%) of phaco group had vision of 6/18 or better at the 8th postoperative week, the ratio was (79%) in large incision group. When best corrected vision be of those whose sutures were removed from large incision extracapsular cataract extraction compared with phaco group, there was no difference. The refraction was stable after the 4th week in phaco group, while still changing up to the 12th week, after removal of suture, in large incision group. Postoperative astigmatism; by refraction, 1.00 D (range 0.50 to 1.50D) in phaco patients, was less than that caused by large incision; 3.25 D (range 1.50 to 5.50D). The comparison between the two groups showed that phaco induced against the rule astigmatism more than large incision extracapsular cataract extraction, and vice versa regarding with the rule against the rule astigmatism.

According to keratometeric values, the large incision cataract surgery induced more postoperative astigmatism; 1.59 ±
1.62 D, than small incision; 0.68 ± 1.02 D. When postoperative astigmatism was compared; in relation to the wound size, large incision (>7 mm) induced more astigmatism; (1.58 ± 1.63 D), than smaller incisions; (3-5 mm) which induced (0.58 ± 0.42 D), while (>5-7 mm) induced (0.74 ± 1.2 D). Regarding the number of stitches, 3-4 stitches had, statistically significant, more surgical induced astigmatism (1.57 ± 1.65 D), compared with sutureless incisions which induced (0.67 ± 1.11D). Interrupted sutures were found to induce significant amount of astigmatism (1.42 ± 1.52 D) more than sutureless wounds (0.67 ± 1.11D). The period of steroid use, in this study, had no significant correlation with the development of postoperative astigmatism.

**Conclusion:** Phaco; compared with large incision extracapsular cataract extraction, had better best corrected vision, rapidly stable wounds and less postoperative astigmatism. Removal of sutures improved vision and postoperative astigmatism in selected patients.
لا يوجد نص يمكن قراءته بشكل طبيعي من الصورة المقدمة.
ـلـبـصـر حـرـج

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INTRODUCTION

Cataract is the major cause of global blindness, accounting for 40 to 80% of all blindness in developing countries. The number of people blind from cataract is expected to rise due to hanging age distribution and increasing life expectancy. There is currently no proven intervention to prevent cataract and surgery is the only form of treatment.\(^1\)

Extracapsular cataract extraction (ECCE) was modified in the 1970s when the use of posterior chamber intraocular lenses was shown to be a safe and effective way of correcting aphakia. In 1980, it was shown that patients who had undergone ECCE had a lower incidence of retinal detachments compared with those that had undergone intracapsular surgery. It was also shown that the incidence of cystoid macular oedema was less in ECCE. These and other facts transformed cataract surgery in the mid-1970s, with a subsequent transition to a smaller wound size, enlarged if necessary to extract the dismantled cataract and introduce the intraocular lens (IOL).\(^2\)

In February 1965 Charles Kelman propounded the view that the ultrasonic tool used at that time by some dentists to help
descaling teeth could be also used to fragment the nucleus of the crystalline lens and allow its removal without the need for a large incision. This liberated a powerful force, previously untried within the eye, but the equipment involved was large, inefficient, and extremely heavy. Nevertheless he and others persevered; Kelman's first operation using phaco on a human eye took 3 hours. Cataract surgery, like many fields today, is undergoing constant change and innovation with improvements in surgical machinery and instrumentation, intraocular lenses, patient comfort, postoperative recovery time, and final visual outcomes. (3)

Cataract extraction by nature is refractive surgery, as surgically induced refractive changes are a result of cataract extraction, intraocular lens (IOL) implantation, and incisional corneal astigmatic changes. The emerging standard in cataract surgery today goes beyond safe cataract removal and proper IOL power calculation to include surgical control of preoperative and induced astigmatism. (3)

Astigmatism occurs when toricity of any of the refractive surfaces of the optical system produces two principal foci delimiting an area of intermediate focus called the conoid of Sturm. Thomas
Young in 1801 was the first to describe ocular astigmatism, discovering that his own astigmatism was predominantly lenticular. However, it was some years later before Airy (1827) corrected astigmatism with a cylindrical lens. Corneal astigmatism was characterised by Knapp and also Donders in 1862 after the invention of the ophthalmometer by Helmholtz. In the same year Donders also described the astigmatism due to cataract surgery and soon after Snellen (1869) suggested that placing the incision on the steep axis would reduce the corneal astigmatism. Surgery to specifically treat astigmatism was suggested by Bates who described corneal wedge resection in 1894, but it was the work of Lans that provided most of the early theoretical basis for refractive corneal surgery.\(^{(3)}\)

Modern refractive cataract surgery followed a 1975 report by Jaffe and Clayman of the results of 1557 cataract extractions. The wounds were closed using various techniques, including 10-0 monofilament Nylon sutures, which started either at 2:30 or 9:30 and were tied at 12:00 (Troutman suture technique) or began at 12:00 and were tied at 2:30 and 9:30 (Willard suture technique). Knots tied superiorly were associated with with-the-rule (WTR)
astigmatism, whereas knots tied close to the horizontal meridian were associated with against-the-rule (ATR) astigmatism. This early report facilitated understanding of the dynamics of suture tension and corneal astigmatism in cataract surgery. It applied vector analysis using graph paper, rectangular coordinates, and the law of Cosines and Sines to determine surgically induced astigmatism. In 1979, Cravy expanded the principles of Jaffe and Clayman by developing an approximate method to categorize postoperative astigmatism as WTR or ATR to help guide suture removal and understand the dynamics of various types of wounds. The incidence of astigmatism >2D following extracapsular cataract extraction is 25-30%; this incidence is lower after phacoemulsification. By introduction of phacoemulsification, surgeons gained the benefit of intraoperative safety, postoperative improved astigmatic results, and faster rehabilitation of small incision surgery. (3)

In the recent years, phacoemulsification was introduced in more than two centers in our country. It is rapidly gaining popularity and the number of patients undergoing phaco surgery is increasing day by day. No study regarding phaco surgery was conducted in Sudan, according to my knowledge. Astigmatic errors are common
postoperative problem following cataract surgery. Different studies worldwide mentioned that phaco is superior to ECCE with PCIOL in solving this problem. We tried to check this fact and to compare our surgery with surgery else where in the world.
LITERATURE REVIEW

EMBRYONIC DEVELOPMENT OF THE LENS:

A knowledge of lens embryology and anatomy is essential to the study of lens function, growth, nutrition and diseases.

At the 4- to 5-mm stage of embryonic development, the surface ectoderm forms the lens plate. By the 5-mm stage, a central depression, the lens pit, forms on the outer surface of the lens plate; as the underlying optic vesicle invaginates, the lens pit also deepens and enlarges to form the lens vesicle.

By the 16- to 18-mm stage, the posterior epithelial cells have elongated and obliterated the cavity of the vesicle, forming the embryonic nucleus. From this point on, no further cellular proliferation occurs in the posterior half of the lens, and all newly formed differentiating lens cells arise from the equatorial portion of the anterior epithelium. (4)

ANATOMIC AND HISTOLOGIC FEATURES:

Topography:

In the pupillary zone, the lens forms part of the posterior boundary of the anterior chamber. The posterior surface of the lens rests in the patellar fossa of the anterior vitreous surface. The
zonule forms the suspensory ligament, which holds the lens in place. \(^{(1)}\)

**Gross structure and dimensions**

The lens is soft, elastic, avascular, transparent, highly refractile, biconvex structure. During early fetal development it is almost spheric, but, as more and more cortical cells develop, it assumes an elliptic shape and increases slightly in size. The anteroposterior diameter averages 3.5 mm in adults, and the equatorial diameter is about 9.0 mm. \(^{(1)}\)

**Transparency:**

The normal lens remains perfectly transparent until maturity. The mechanisms of this remarkable feature are incompletely understood, but they undoubtedly include the absence of blood and lymph vessels, nerves, and intercellular connective tissue, the uniform arrangement of the cells in the axial portion of the lens and the absence of nuclei. \(^{(1)}\), \(^{(3)}\)

**Opacification:**

One theory is that the initial increase in light scatter in the cataractous lens is brought about by conformational changes in protein structure that introduce sufficient disorder in the cell
cytoplasm to interfere with light transmission. These conformational changes concurrently lead to increased susceptibility to proteolysis and hydration with further loss of transparency. (3), (5)

**Cataract types:**

The three most common kinds of cataractous opacifications that are noted clinically are nuclear sclerosis, posterior subcapsular cataract (PSC), and cortical cataracts. (3)

1- **Nuclear sclerosis:**

Metabolic changes within the cells lead to color changes, most commonly yellow and brown, which further attenuate the passage of light through the lens. Nuclear sclerosis increases the refractive power of the lens. The result is increased myopia. (1), (3), (5)

2- **Posterior subcapsular cataract:**

As fiber cells migrate posteriorly, they may become dysplastic and enlarged. These dysplastic fiber cells tend to congregate in nests, surrounded by normal fiber cells. The clinical appearance at the slit lamp is a posterior subcapsular cataract. PSC, commonly, result in glare from diffraction and scatter of light rays as they pass through the posterior part of the lens. Since the posterior capsule is close to the nodal point of the eye, central PSC cataracts often
result in distortion or blurring of vision, particularly for reading, even when they are small. (1), (3), (5)

3- Cortical cataract:

Injuries to the fiber cell mass in the teenage years will not result in clinical opacity until middle age. Such opacities are cortical cataracts, which may be either anterior or posterior, depending on the location of the first injured fiber cell. (1), (3), (5)

Etiologies of cataract in adults

1- Aging:

It is, of course, the most common reason adults develop cataracts. (1), (3), (5)

2- Metabolic:

Metabolic abnormalities can cause cataracts in adults as well. Wilson's disease "sunflower cataract." and Sugar cataracts, particularly from diabetes and Galactosemia "oil droplet" cataracts in infancy are known types. (1), (3), (5)

3- Trauma:

Trauma is an important cause of cataracts in adults, either blunt trauma or direct perforation. (1), (3), (5)
4-Inflammation:

Prolonged inflammation is a common cause of cataract in adults. Uveitis "complicated cataract." And the treatment of uveitis may be a cause of cataract. (1), (3), (5)

5- Toxic cataracts:

Drugs may result in a toxic type of cataract. Systemic drugs such as corticosteroids, topical miotic drops such as Pilocarpine and, more commonly, the anticholinesterase inhibitors cause cataract with extended usage. (1), (3), (5)

6- Systemic diseases:

Some systemic diseases are associated with lens changes. Myotonic dystrophy is associated with lens opacities in 90% of cases. These tend to be small, colourful opacities scattered throughout the cortex, and usually are not clinically significant. (1), (3). (5)
Cataract Surgery

Indication for cataract surgery:

1) Visual improvement: Is by far the most common indication, although requirements vary from person to person.

2) Medical indications: Are those in which the presence of cataract is adversely affecting the health of the ages for example phacolytic glaucoma, intumescent cataracts or diabetic retinopathy, treatment of which is hampered by cataract.

3) Cosmetic indications: Are those in which a mature cataract in an otherwise blind eye is removed to restore black pupil. \(^{(6)}\), \(^{(7)}\)

Patient preparation:

Certainly the patient is entitled to learn about each of the following when cataract surgery is contemplated:

1. The need for the operation.

2. The alternatives to surgery.

3. Inpatient versus outpatient surgery, and the need for preoperative testing.
4. The role of preexisting medical disorders.

5. Possible risks and complications, including anesthetic, operative, and postoperative difficulties.

6. The types of optical correction available as well as when the final correction will be given. The patient must be instructed if the surgeon finds it injudicious to implant an intraocular lens, and the limitations of aphakia vision.

7. The duration of recuperation and limitations during this time.

8. The probable ultimate visual outcome if there are no complications.

9. Surgical fees and insurance coverage.

   Often, much of the above information can be provided with preprinted material, videotapes, or by an office assistant. (2)

**DIAGNOSTIC PROCEDURES:**

**A- History:**

As in most areas of medical practice, the patient's history is all-important. The important points to be noted in the history include the following:

1. Previous ocular disease, such as trauma, amblyopia, glaucoma, infections, inflammatory episodes, and information regarding any
topical medications that have been or are being applied by the patient.

2. Similar surgery (especially cataract surgery) on the fellow eye. There is a remarkable symmetry characteristic of certain complications that may be due to host factors, such as poor wound healing, hemorrhage, vitreous loss, capsular rupture, and infection.

3. Vocational or other needs. For those whose visual requirements are not so demanding, the indications for cataract surgery might be less compelling.

4. Medical history. It has often been stated that poor general health is in itself not a contraindication to cataract surgery. Nevertheless, various systemic illnesses might well influence the need for improved vision or, conversely, might make surgery riskier or the postoperative period more prolonged. The following medical factors should be considered in determining whether or not to perform surgery:

1. The patient's life expectancy.

2. Diabetes, its control together with the presence of retinopathy and systemic complications.
3. Systemic hypertension, its control as well as its importance as a predisposing factor in operative hemorrhage.

4. Obstructive urinary tract, particularly if osmotic agents are to be employed prior to or during surgery.

5. Chronic pulmonary disease with coughing spells during and after surgery.

6. Obesity with elevated intraocular pressure at surgery.

7. Medications taken, such as anticoagulants, which might produce intraoperative hemorrhage, and corticosteroids requiring adrenocorticotropic hormone and postoperative maintenance.

8. Ischaemic heart disease.

9. History of renal disease, especially the presence of urinary calculi, particularly if carbonic anhydrase inhibitors are to be used postoperatively

10. Senility with mental confusion. (2), (5)

B-Visual acuity:

The aspect of visual function that receives the most attention with regard to cataract is that of visual acuity. Distance vision should be tested in a lighted room as well as in a dimly lit room. Near vision should be checked as well, since it is not uncommon for a
discrepancy to exist between near and distance visual acuity in cataract patients. (For example, patients with posterior subcapsular cataracts frequently have better distance than near visual acuity, while those with nuclear sclerosis tend to have better near than distance visual acuity.) Naturally, a careful refraction with pinhole and lenses should be performed. In patients who have subjective complaints greater than what would be expected from their Snellen visual acuity test, glare testing may be indicated. (2), (5)

C- Examination of the pupil:

The pupillary response to light should be brisk even in the presence of a mature cataract. If this is not the case, one should suspect optic neuropathy.

The degree of pupillary dilation in response to mydriatics and cycloplegic solutions should be noted. If the pupil will not dilate widely, extra steps will be needed at the time of surgery to allow adequate access to the lens. This may consist of stronger mydriatics, topical nonsteroidal anti-inflammatory drugs, epinephrine added to the irrigating solution, iridectomy, or sphincterotomy. (2), (5)
D- Examination of adenxa:

One should evaluate the eyelids and lacrimal apparatus carefully for the possibility of problems that might be associated with infection, keratitis, or faulty wound healing. One should be aware of even minor degrees of blepharitis, ectropion, entropion, lagophthalmos, keratoconjunctivitis sicca, and dacryocystitis. Appropriate measures, including prophylactic medical treatment or even surgical correction, should be undertaken prior to performing the cataract surgery. (2), (5)

E- Slitlamp examinations:

The following features are significant if discovered during the preoperative evaluation.

1- Cornea Guttata:

Cornea guttata indicate early corneal endothelial dysfunction that might result in clinically significant corneal decompensation. One should take extra care to prevent corneal damage during surgery by avoiding corneal bending, excessive insertion of instruments into the anterior chamber, and excessive irrigation of the anterior chamber. Specular microscopy has emerged as an important technique in the evaluation of the corneal endothelium. It
should be recognized that this technique provides information about only the morphology of endothelial cells, not their function. However, a low cell density (400 to 700 cells/ mm²) implies compromised function, and specular microscopy is now widely used to detect impending corneal decompensation.

2- Shallow Anterior Chamber:

One should take care to prevent iridodialysis when enlarging the incision with scissors, as well as inadvertent rupture of what one might expect to be a fragile capsule surrounding a swollen lens.

3- Dense Posterior Synechiae:

One should look for preexisting complications of uveitis, such as glaucoma and retinal scarring, as well as for the possibility of recurrent uveitis in the postoperative period.

4- Iridodonesis and Phacodonesis:

Iridodonesis is the sign of a dislocated or subluxated lens, possibly in conjunction with vitreous in the anterior chamber.

5- Coexisting Glaucoma And Cataract:

As a general rule, one may perform routine cataract extraction if glaucoma has been well controlled. In most cases, control will be no more difficult and may be more easily achieved postoperatively.
When glaucoma control is poor and unrelated to the lens itself, such as in chronic open-angle glaucoma, then a combined cataract-glaucoma procedure should be considered. In cases of glaucoma secondary to lens pathology, such as in phacolytic glaucoma or with an intumescent lens and secondary angle-closure glaucoma, cataract extraction alone may control the glaucoma if this is done before optic nerve function is destroyed. It is wise to measure intraocular pressure at least once during the immediate postoperative period, usually on the first postoperative day, because pressure elevation may occur silently.\(^{(2)}\)

**Evaluation of visual function in an eye with mature cataract:**

One should not assume that the fundus cannot be visualized when a cataract is present. Often, even in the presence of advanced cataract changes, the fundus can be seen through a widely dilated pupil by use of the indirect ophthalmoscope. One should attempt to evaluate the macula, the optic disc, and the fundus periphery, particularly by evidence of retinal tears, detachments, or tumors. Nevertheless, many patients present with cataracts that do not permit ophthalmoscopic observation. For these patients the following techniques might be employed.
1- Pupillary response:

   No cataract is truly opaque. As described previously, pupillary responses should appear normal; and if an afferent defect is present, it should be taken as presumptive evidence of an optic nerve lesion. (2), (8)

2- Light projection and two-light discrimination:

   Light projection and two-light discrimination are crude forms of visual field testing and give important information about a visual function (the light sense) that is fundamentally different from that provided by testing of visual acuity. (2)

3- Colour vision:

   Can also be tested by asking the patient to identify which colour filter is being used in front of a test light. The tests in this group give indications of retinal function and should not be interpreted as being due solely to macular function. (2), (8)

4- Entoptic phenomena:

   A small light illuminating the interior of the globe through the eyelids and sclera produces for many individuals the sensation of seeing a pattern of branches or cracks. This is the result of self-visualization of the retinal vessels. When it can be elicited, it can be
a useful indicator of the presence of retinal function, but, unfortunately, this is a highly variable phenomenon. The blue field entoptic phenomenon also relies on a subjective response that of seeing one's own white corpuscles. It is also a distressingly variable effect. (2), (8)

5- Potential acuity meter:
The potential acuity meter attaches to a slit lamp and permits projection of Snellen optotypes onto the patient's retina through a 0.2-mm 2 apertures in the lens opacity, if one can be found. It is generally reliable, but its accuracy is decreased if the patient has advanced glaucoma.

6- Laser interferometry:

The coherent light of a low power laser can be used to produce grid (grating) patterns of various widths, and these patterns are little affected by lens opacities. There is a tendency for this test to overestimate acuity, especially in patients with coexisting amblyopia. (2), (8)

7- Ultrasonography:

A "view" of the interior of the globe can be obtained with sound waves rather than light waves, producing an acoustic picture
of the interior of the eye. Patterns of vitreous hemorrhage, retinal
detachment, and intraocular tumors are well known. Compared with
ophthalmoscopy, this technique is less precise for visualizing the
ocular fundus.

Another important use of ultrasonography is the measurement
of the axial length of the eye. This value is an important calculation
of intraocular lens power. (2), (8)

8- Visual electrophysiology:

Electroretinography (ERG) records the electrical response of
the entire retina to light stimulation. However, in a patient with
opaque media, it is not possible to determine whether macular
function is intact using this technique. The visually evoked potential
(VEP) is the averaged electrical response from the visual cortex to
repeated light stimulation. Because the macular area of the retina is
much more heavily represented centrally than is the retinal
periphery, the electrical response that is recorded is closely related
to visual acuity. Any abnormality coexisting with a cataract, such as
macular degeneration, optic atrophy, or amblyopia, will produce an
abnormal VEP, whereas a patient with cataract alone, but otherwise
normal visual pathways, will show an intact VEP response. (2), (8)

**Coexisting cataract and corneal opacity:**

Many patients with corneal opacities as well as cataracts can have an excellent visual result if cataract surgery alone is done, particularly if the opacity is paracentral and is not associated with irregularities of the corneal surface. (2)

**Refractive error of the other eye:**

With the use of lens implants, ophthalmologists have the opportunity to select the approximate refractive error of the operated eye. While emmetropia to mild myopia is usually ideal, this may not be tolerated in a patient with a large refractive error in the fellow eye. Patients usually tolerate only 3 D of anisometropia; therefore, the refractive state of the fellow eye is an important consideration. Patients should be advised on aniseikonia, diplopia, spectacle thickness, and advantages of myopia, and should participate in selecting the best refractive error for their needs. (2), (8)
PREOPERATIVE MANAGEMENT

1- Lowering the intraocular pressure:

It is desirable to reduce intraocular pressure prior to cataract surgery in order to minimize the effects of several difficulties that can develop during the operative procedure.

a) Medications:

Osmotic agents such as oral Glycerol, oral isosorbide, or intravenous Mannitol may be administered 1 to 2 hours prior to surgery. Glycerol is contraindicated for diabetic patients. Acetazolamide, a carbonic anhydrase inhibitor, may be administered orally or parenterally in a dose of 250 to 500 mg the evening before or the morning of surgery. (2)

b) Eyelid akinesia and retrobulbar anaesthesia or general anesthesia:

Elimination of the actions of the extraocular muscles as well as blockage of the ciliary ganglion nerve results in lowered intraocular pressure. The pressure-lowering effect of general anesthesia may include the additional factor of elimination of central pressure regulatory mechanisms. (2)
c) Pressure on the globe:

Immediately following administration of a retrobulbar block, some pressure should be put on the globe through the closed eyelids. The aim is to compress any vessel that might be nicked by the needle and to reduce intraocular pressure.\textsuperscript{(2)}

\textbf{2- Management of the pupil:}

Wide dilation of the pupil preoperatively is desirable and even mandatory for certain procedures, such as phacoemulsification. A combination of an adrenergic substance such as Phenylephrine 2.5% together with an anticholinergic preparation such as Tropicamide (Mydriacil) 0.5% or 1% or Cyclopentolate (Cyclogyl) 0.5% or 1% one to four times at 5- to 15-minute intervals 1 to 2 hours prior to surgery will achieve this effect. Miotic agents such as Pilocarpine should be discontinued 3 days prior to surgery. If adequate pupillary dilation is not obtained with the above regimen, a drop of 10% Phenylephrine may be applied if there is no systemic contraindication.\textsuperscript{(2), (5)}

Flurbiprofen (Ocufen) is a topical nonsteroidal anti-inflammatory drug that inhibits intraoperative miosis.\textsuperscript{(9)} Intraoperative miosis can also be inhibited by the addition of 0.5 ml
of intracardiac Epinephrine 1: 1000 to the 500-ml bottle of intraocular.\(^{(2)}\)

3- **Preoperative and Intraoperative Tranquilization:**

Many modern tranquilizers, such as Diazepam (Valium), induce not only a state of well being but have sedative and antiemetic effects as well. Unfortunately, occasional patients, particularly the elderly, manifest idiosyncratic responses, ranging from restlessness and mental confusion to agitation, delirium, coma, and even death. A newer Benzodiazepine, Midazolam (Versed), is gaining interest. It is useful for preoperative sedation and has stronger amnestic properties than that of diazepam. Propofol (Diprivan), a new intravenous (IV) anesthetic, given by IV bolus, offers rapid onset of anesthesia, total amnesia, and rapid recovery (15 minutes), and may prove useful if administered just prior to the retrobulbar block.\(^{(2)}\)

4- **Anaesthesia:**

It may be said that anaesthesia is for the patient and akinesia is for the surgeon.

a) General anaesthesia: may be preferred for procedures expected to take longer or for uncooperative patients. General anaesthesia
offers the advantage of virtually complete immobility of the globe. However, there are several disadvantages associated with the use of general anesthesia: patients have more risk of systemic complications, there is no associated postoperative analgesia, incidence of vomiting and Valsalva maneuvers are increased, and recovery from the anaesthetic agent is prolonged, making same-day surgery difficult.

b) Retrobulbar anaesthesia: with a separate facial nerve block continues to be the preferred form of local anaesthesia. However, there is increasing interest in peribulbar anesthesia. Retrobulbar anaesthesia may have a more rapid onset, whereas peribulbar anesthesia may have a lower risk of retrobulbar hemorrhage, damage to the optic nerve, and inadvertent injection into the optic nerve sheath. A modified Van Lint facial block may be administered for facial akinesia by injecting 4 to 7 ml of anaesthetic subcutaneously into three locations: anterior to the ear, along the temporal, superior orbital rim, and along the temporal inferior orbital rim. It is also possible to perforate the globe, especially when using a very sharp, disposable needle. This accident occurs most frequently in highly myopic eyes. (2), (7)
c) Topical anaesthesia: can be used in small incision surgeries, it can be supplemented by intracameral nonpreserved Lidocaine. It needs cooperation of the patient, but its advantages include no risk of ocular perforation or retrobulbar haemorrhage, elimination of diplopia postoperatively, vision returns almost immediately and patients are able to leave the operating room without patching. Topical anesthesia can be administered as drops, Cellulose pledgets or Lidocaine jelly. (5), (10)

5- Cleansing of the surgical field:

Skin preparation is performed with a standard soap solution containing iodine. The area extending from the midline to well above the eyebrow and well below the cheek should be scrubbed for 3 to 5 minutes. The eye and the conjunctival cul-de-sacs are irrigated thoroughly with copious quantities of body-temperature saline to remove any mucous strands. The skin is then thoroughly dried with lint-free towels to permit adequate adherence of the adhesive drapes to the eyelids. An incision is made through the drape ending 0.25 cm beyond the inner and outer canthi. With a muscle hook, the free edges of the drape are inverted behind the upper and lower eyelids and an eyelid speculum is applied. (2) The routine
preoperative use of antibiotics such as topical Gentamicin or Polymyxin plus Trimethoprim (Poly-trim), may reduce the incidence of operative infections even further. \(^{(2)}\)

6- **Grasping the superior rectus muscle:**

Grasping the superior rectus muscle is performed by a pair of 0.3-mm or 0.5-mm toothed forceps. The needle with an attached 4-0 black silk suture is then placed through the conjunctiva beneath the muscle tendon and on through the conjunctiva on the other side. Gentle traction is obtained by looping the two ends through the open jaws of a hemostat, which is then clamped to the drapes. Too much tension on the bridle suture may cause posterior vitreous pressure and may contribute to postoperative ptosis due to damage of the connections between the levator palpebrae and the superior rectus muscles. Many surgeons prefer not to use this technique unless eyelids cover the superior limbus. \(^{(2)}\)

7- **Retesting intraocular pressure:**

Prior to incision into the globe, intraocular pressure should be tested again. Palpating the globe with an instrument such as a forceps or muscle hook can do this, although some surgeons prefer to have a sterilized tonometer available for this procedure. \(^{(2)}\)
TYPES OF SURGERY:

1- INTRACAPSULAR CATARACT EXTRACTION (ICCE).

2- EXTRACAPSULAR CATARACT EXTRACTION (ECCE).

3- PHACOEMULSIFICATION.

4- LASER PHACOLYSIS.

5- CLEAR LENS EXTRACTION.

1- INTRACAPSULAR CATARACT EXTRACTION (ICCE):

Intracapsular extraction is appropriate even today; in certain conditions, and for that reason the technique is discussed here. It has the advantage of removing the lens as a hall, but the incidence of complication is higher than ECCE with IOL, such as CME, RD, vitreous loss and endophthalmitis. In addition, the problems of aphakia. (11)

The vision in aphakia:

The dioptric apparatus in aphakia has been reduced to single refracting surface (the corneal bounding the a medium of uniform refracting index the aqueous and vitreous). The image is normal 31 mm; behind the cornea, and the anterior principal focus is 23.22 mm in front of the cornea instead of 17.05 mm. The dioptric
system is strongly hypermetropic, therefore, must be corrected by strong converging lens; of about + 10 D.\(^{(12)}\)

**The disadvantages of aphakia:**

1) Enlargement of the image size: The image in aphakic eye, corrected by spectacles in their usual position, is about 25% larger than when the eye is phakic. The visual acuity is therefore worse than is indicated by clinical tests.

2) The visual co-ordination is disturbed after aphakia due to a false spatial orientation of familiar orientation. So, the patient may pour water onto the table instead of into the glass.

3) Loss of binocular vision may present if the other eye is phakic due to aniseokonia.

4) All accommodation is abolished, so the patient needs two glasses one for distant and another for near vision. Artificial accommodation can be attained by moving the spectacles up and down the nose.

5) Limitation of visual field: the spectacles do not move with eyes, and the prismatic effects of their periphery are great so that, the patient uses the central portion of his lens.

6) Distortion of the peripheral objects due to spherical aberration.
7) Ring scotoma is due to the prismatic deviation of the periphery; increase with moving the image.

8) The proper optical correction may be difficult due to high incidence of astigmatism with high degrees.\(^{(12)}\)

**Procedure:** First, a large incision, conjunctival or limbal, about 12-14 mm is made. To facilitate lens extraction, enzymatic zonulolysis with A-Chymotrypsin is employed virtually routinely by many eye surgeons. Cryoextraction is most easily performed with an assistant who gently retracts the cornea with the attached limbal-based conjunctival flap, or a suture loop. The iris must be retracted adequately so that the cryoextractor can be applied to the anterior and superior midperiphery of the lens. If 2 or more minutes have been allowed to elapse following irrigation with A-Chymotrypsin, the strength of the zonular membrane is usually much reduced. The remaining zonules are usually broken by gentle traction as the lens extraction is initiated, and remaining zonules break by an "unzipping" action.\(^{(2)}\)\(^{(5)}\)
2- LARGE INCISION EXTRACAPSULAR CATARACT EXTRACTION (ECCE):

Extracapsular cataract extraction has become a preferred technique, as there is good evidence for reduced complications such as cystoid macular oedema and better tolerance of posterior chamber intraocular lens implants, which was encountered in ICCE. (13)

Surgical techniques in extracapsular cataract extraction:

1) A vertical groove is made in the peripheral clear cornea, surgical limbus. Some surgeon make conjunctival flap first. The cystitome is introduced into the anterior chamber and multiple small radial cuts are made in the anterior capsule. For 360°, an alternative method is capsulorrhexesis, which involves making a controlled circular tear in the capsule.

2) The full-thickness corneal incision is completed with scissors.

3) The nucleus is expressed by alternating pressure from above and below.

4) The tip of the infusion / aspiration cannula is introduced into the anterior chamber and passed under the iris, first, at 6 o’clock strands of cortex are engaged into the port by suction, the cortex is
then dragged centrally and aspirated under direct visualization. The manoeuvre is repeated sequentially until all cortex has been removed. Posterior capsule can be polished to remove residual subcapsular plaques.

5) Viscoelastic substance is injected into the capsular bag to facilitate subsequent insertion of the IOL.

6) The IOL is grasped by the optic and its anterior surface coated with viscoelastic substance.

7) The inferior haptic is inserted through the lips of the incision then passed under the iris at 6 o’clock.

8) The tip of the superior haptic is grasped with forceps and advanced into the anterior chamber. As the superior pole of the haptic is clearing the edge of the pupil, the arm is pronated to ensure that on release of the haptic will spring open under the iris. Preferably, both haptics should be placed into the capsular bag and not into the ciliary sulcus.

9) The IOL is dialed into the horizontal position by engaging the guide holes with especial hook.
10) The pupil is constricted by injecting Michol Acetylcholine into the anterior chamber, viscoelastic substance is aspirated, and interrupted or continuous sutures close the incision.\(^{(6),(11)}\)

3- PHACOEMULSIFICATION:

Newer forms of extracapsular cataract extraction have been developed, namely, phacoemulsification and phaco-fragmentation. Phacoemulsification consists of emulsifying the lens with ultrasonic power and removing the lens remnants with aspiration. Phaco-fragmentation is in essence the same; however, the lens particles are removed with a vitrectomy device. The new techniques carry the advantages small incision; 3-4 mm, closed anterior chamber during surgery and rapid visual rehabilitation after surgery.\(^{(11)}\)

**Instruments:**

The instruments used in phacoemulsification involve both ultrasonics and dynamics.

**A) Ultrasonics terminology.**

- **Cavitation:** The formation of vacuoles in a liquid by a swiftly moving solid body, such as the ultrasonic tip. The collapse of the vacuoles release energy that vaporizes and crushes lens material.
• **Chatter:** To cut unevenly with rapidly intermittent vibration. Chatter occurs when the ultrasonic stroke overcomes the vacuum, or “holding power”. This causes nuclear fragments to be repelled by the ultrasonic tip until the vacuum reaches high enough levels to neutralize the ultrasonic tip’s repulsive energy. Chatter inhibits followability.

• **Frequency:** Is how fast the phaco needle moves back and forth. The frequency of current ultrasonic handpieces is between 27,000 – 60,000 strokes per second.

• **Load:** Occurs when the ultrasonic tip encounter nuclear material. It requires that the system and ultrasonic tip maintain constant stroke length or power. Load is constantly changing.

• **Piezoelectric:** Is a transducer in the hand piece that transforms electric energy into mechanical energy.

• **Power:** The ability of the phaco needle to vibrate and cavitate the adjacent lens materials. The percentage of power is proportionate to the stroke length.

• **Stroke:** A sudden action or process producing an impact, which is measured by the magnitude of tip movement (27,000 – 60,000 Hz).
• **Tuning:** The method used to match the optimum driving frequency of the ultrasonic board within the console with the operating frequency of the phacoemulsification handpiece.

• **Ultrasonic:** Frequencies above the range of human audibility, or above 20,000 vibrations per second. The phaco needle moves in excess of 20,000 times per second.

**B) Fluidics terminology:**

• **Aspiration flow rate:** The rate at which the fluid is removed from the eye.

• **Followability:** The ability of a fluidic system to attract and hold nuclear or cortical material on the distal end of an ultrasonic or irrigation / aspiration handpiece. It depends on the pressure difference between the IOP and aspiration port.

• **Occlusion:** An obstruction of the aspiration port by nuclear or cortical material. It is necessary to create vacuum.

• **Rise time:** The rate at which vacuum builds once the aspiration port has been occluded. It is directly related to the aspiration flow rate, which is related to the pump speed.

• **Surge:** A phenomenon that occurs when the occlusion is suddenly broken, leading to the fluid in the higher – pressure
(positive) anterior chamber tending to rush into the lower-pressure (negative) phaco tip.

- **Vacuum**: The suction force (negative pressure) exerted on the fluid in the aspiration line of the eye. The higher the vacuum, the greater the holding force for material that occluded the aspiration port. It is measured in mmHg or inches of water.

- **Venting**: The process whereby negative pressure is equalized to atmospheric levels to minimize the surge. (11)

**The phaco handpiece contains three lines:**

1) Ultrasound power line.

2) Irrigation line.

3) Aspiration line.

**1-Ultrasound:**

The phaco handpiece contains a piezoelectric crystal that vibrates at a frequency of 27,000 – 60,000 Hz, which is transmitted to the phaco tip, when the primary oscillation is axial. Phaco tips are available in angles of 0°, 15°, 30°, 45°, 60° and combined 30° / 60° (turbo) bend tips. The lower angle beveled tips are better for engaging nuclear material, whereas steeper tip bevels are better for cutting.
The newer, variable power phaco machines provide active control of aspiration and vacuum, using the phaco power secondarily. This has led to the use of lower power, that is, only enough to fragment and aspirate the nuclear material.

2- **Irrigation**: Or fluid inflow, delivered from an external bottle, is gravity driven and in a closed system.

3- **Aspiration**: Varies according to the pump design:

1) **The peristaltic pump**: consists of a set of rollers that move along a flexible tubing, forcing fluid through the tubing and creating a relative vacuum at the aspiration port. Advantages of this system are the relatively rapid stepwise rise in pressure and the independent control of vacuum and aspiration flow rate. \(^{(11)}\)

2) **The diaphragm pump**: consists of a flexible diaphragm overlying a fluid chamber with 1-way valve at the inlet and outlet. The diaphragm moves out creating a relative vacuum in the chamber that shuts the exit valve, causing fluid to flow into the chamber. The diaphragm then moves in, which increases the pressure in the chamber and closes the inlet valve while opening the exit valve. It produces slow rise in vacuum. \(^{(11)}\)
3) **Venturi pump**: It creates a vacuum based on the venturi principle: “A flow of gas or fluid across a port creates a vacuum proportional to the rate of flow after gas”. It produces a rapid linear rise in the vacuum and allows for instantaneous venting to the atmosphere. (11)

**Important steps in phacoemulsification**:  
Phaco procedure is similar to ECCE except in certain steps, such as incision size, opening of the anterior capsule, hydrodissection and removal of the nucleus. (11)

1- **Capsulorhexis**:

For many years, a "can-opener" capsulotomy was considered a satisfactory way to gain access to the nucleus for both planned extracapsular cataract extract and phaco. Problems related to malpositions and decentrations of the implanted PC IOL were later recognized. In 1991, Wasserman and associates performed a postmortem study that showed that the extension of one or more V-shaped tears toward the equator produced instability of the IOL and resulted in IOL malposition. At this point, these findings were sufficient cause for us to reconsider the use of can-opener anterior capsulotomy; we also recognized that multiple capsular tags and
V-shaped capsular incisions directed to the peripheral aspect of the lens could impede the new phaco techniques that were emerging. We were fortunate to have benefited from the work of Gimbel and Neumann, who described the method of continuous curvilinear capsulorhexis (CCC), in which the surgeon makes a continuous circular or curvilinear tear in the anterior capsule that can withstand the forces imposed on the capsule opening during both phaco and IOL implantation. Postoperative, eyes underwent CCC with PC IOL seemed to preserve pseudo-accommodation.

**Technique:**

The technique of CCC is not difficult to learn if certain basic principles are observed:

1- The continuous capsular tear should be performed in a deep, stable anterior chamber. The use of a viscoelastic material accomplishes two important goals:

A. It creates space for safe instrumentation in the anterior chamber.

B. It resists the action of posterior pressure, which tends to cause the capsular tear to move more peripherally.

2- The tear is started toward the center of the capsule. A desirable goal is for the capsulorhexis to be completed from the outside in.
3- Mobilizing and everting the anterior capsular flap permits controlled tearing of the continuous curvilinear capsulorhexis.

4- The continuous tear proceeds either clockwise or counterclockwise in a controlled and deliberate fashion, the surgeon regrasping with the forceps or repositioning the point of the cystotome-bent needle on the inverted flap to control the vector of the tear. Upon completion of the CCC, it is essential that the origin of the peripheral portion of the CCC be included within the circumference of the tear.\(^{1,2}\) In mature cataract, the red reflex is absent, so the anterior capsule is difficult to be visualized. Some surgeons use certain dyes, such as fluorescein Sodium, Indocyanine green and Trypan blue, to enhance visualization of the capsule.\(^{15}\)

**2- Hydrodissection and hydrodelination:**

Hydrodissection is used to separate the cortex from the surrounding capsular bag. Hydrodelination is used to separate the central, denser nucleus from the surrounding less dense epinuclear layer. Each of these techniques is accomplished by injection of a balanced salt solution through a straight or curved cannula in the appropriate anatomic plane\(^{1,2}\)
**Technique:**

A 26-gauge cannula attached to a balanced saline-filled syringe is introduced beneath the anterior capsule. The cannula tents up the anterior capsule in this area and is advanced peripherally. At this juncture, saline is injected gently to create a fluid wave that passes around the equator of the lens. The injected fluid causes the lens material to move forward, indicating that although most of the attachments are broken, there are still areas of contact that keep the fluid from moving freely around the lens. The same cannula, but without irrigation, it is placed on the central portion of the lens and depresses the lens mass posteriorly, which forces the posteriorly trapped fluid around the lens periphery to exit through the CCC opening. This process may be repeated in another adjacent quadrant to ensure complete cortical cleaving. Before beginning phaco, the surgeon should make certain that the lens material rotates freely within the capsular bag. This facilitates lens removal techniques, decreases the time for surgery and ensures access to all lens material within the capsular bag.\(^{(16)}\) If the lens material does not rotate fully, additional hydrodissection is warranted.\(^{(2),(5)}\)
3- Nucleus-dividing techniques:

The goals of all these techniques are to:

1) Insure safety in removal of nuclear material.
2) Avoid rupture of the posterior capsule.
3) Decrease the time needed of surgery.
4) Provide comfort for surgeons. \( ^{(11)} \)

A- Moderately hard to dense brunescent nuclei:

1- Crater divide and conquer technique:

Divide and conquer nucleofractis phaco, described by Gimbel, was the first nucleofractis (two instruments) cracking technique developed. It is still used for hard lenses and is now combined with the phaco chop for dense brunescent nuclei.

After adequate hydrodissection, a deep crater is sculpted into the center of the nucleus, leaving a dense peripheral rim. Once a central crater is created, bimanual fracture of the nuclear rim into smaller wedges for controlled phacoemulsification is performed. \( ^{(2)} \).

2- Phaco fracture technique:

In phaco fracture, a widely used nucleofractis technique described by Shepherd, the surgeon sculpts a groove from the
12- to 6-o'clock position after performing hydrodissection and hydrodelineation. The width of the groove should be one and a half to two times the diameter of the phaco tip. Using the phaco handpiece and a second instrument, the surgeon rotates the nucleus 90°. A second groove is sculpted perpendicular to the first, in the form of a cross. A bimanual cracking technique is used to create a fracture through the nuclear rim in the plane of one of the grooves. The nucleus is then rotated 90°, and additional fractures are made until four separate quadrants are isolated. The segments are then tumbled toward the center of the capsule for safe emulsification. (2), (5)

**B-Soft to moderately hard nucleus:**

1- *The trench technique*:

Gimbel described the trench technique, in which a deep trench is made slightly to the right of the central position of the nucleus, which is stabilized by a second instrument introduced through the paracentesis. When the groove is deep, the nucleus is cracked with a bimanual technique. Sequential fractures are made until thin, wedge-shaped pieces of nucleus remain. These pieces are then drawn to the center of the capsular bag for emulsification.
The second instrument stabilizes the nuclear segments during emulsification and can be used to protect the posterior capsule from the phaco tip. ², ⁵

2- *Chip and flip technique:*

Introduced by Fine, this procedure relies on a nucleus that rotates freely within the capsular bag. Initially a central bowl is sculpted in the nucleus until a thin central plate remains. The second instrument introduced through the side port incision engages the subincisional nuclear rim to move the inferior nuclear rim toward the center of the capsule bag. Then clock-hour pieces of the rim are carefully emulsified as the nucleus is rotated. Once the entire rim is removed, the second instrument is used to elevate the remaining central thinned nuclear plate, which is then emulsified. The epinucleus is engaged at the 6-o'clock position with aspiration alone. As the phaco tip is moved superiorly, the second instrument pushes the epinucleus toward the 6-o'clock position, thereby tumbling the epinuclear bowl and permitting it to be aspirate. ², ⁵

3- *Crack and flip technique:*

Fine and colleagues modified Shepherd's phaco fracture technique by adding hydrodelineation, resulting in the crack and flip
technique. Sculpting two deep grooves at right angles to each other that extend to the golden ring permits bimanual nucleus cracking. Only the endonucleus cracks, since the epinucleus is separated from it by hydrodelineation. Each quadrant is then sequentially removed with the use of pulsed phaco and moderate aspiration. Once the nucleus is removed, the epinucleus is aspirated as with the chip and flip technique. (2), (5)

4- The phaco chop technique:

The phaco chop technique was initially introduced by Nagahara, who used the natural fault lines in the lens nucleus to create cracks without creating prior grooves. The phaco tip is embedded in the center of nucleus after the superficial cortex is aspirated. A second instrument; the phaco chopper, is then passed to the equator of the nucleus, beneath the anterior capsule, and drawn to the phaco tip to fracture the nucleus. The two instruments are separated to widen the crack. This procedure is repeated until several small fragments are created, which are then emulsified. (2), (5)
**Sculpting techniques:**

*a) Down-slope sculpting:*

Gimbel developed the down-slope sculpting technique to provide a safe alternative to current sculpting techniques. It is especially useful in eyes with poor pupillary dilation. With traditional sculpting methods, the phaco tip is perpendicular to the posterior capsule at the end of the phaco stroke, thus jeopardizing the integrity of the capsule with each pass. With the down-sloping technique, phaco sculpting occurs parallel to the posterior capsule, decreasing the risk of rupture of the posterior capsule. (2), (5)

*b) Phaco sweep:*

In traditional sculpting techniques, the phaco probe is moved from the proximal to the distal portion of the nucleus to create a groove. Using the phaco probe in a lateral motion (i.e. perpendicular to the incision), Gimbel and Chin introduced the phaco sweep technique, a variation of down-slope sculpting, by which the central nucleus is sculpted quickly and deeply while constant visualization of the tip of the instrument is maintained. They prefer to use a 45° Kelman phaco tip because this tip allows efficient removal of lens material and is easy to use. The increased
cavitation produced by this tip occurs because of the larger cross-sectional area of the lumen of the tip. Additionally, the bend of the tip focuses the ultrasound energy down into the nuclear mass, increasing the efficiency of the phaco.\(^{(2),(7),(11)}\)

**Management of the cortex:**

Vigilance must be maintained, however, as many experienced phacoemulsification surgeons break the capsule or encounter other complications more frequently during cortical cleanup than during phacoemulsification of the lens nucleus. The effective removal of the lens cortex is dependent on the successful application of prior portions of the procedure, especially capsulorrhexis construction and hydrodissection. A capsulorrhexis that is too small makes the purchase of the subincisional cortex challenging. In addition, adequate hydrodissection earlier in the procedure effectively hydrates the cortex facilitating its removal. Following phacoemulsification, the cortex usually lines the inner aspect of the capsular bag. It is most easily removed by engaging the free end of the cortical sheet under the anterior capsule with moderate levels of vacuum and peeling the cortex from anteriorly to posteriorly as the I/A tip is moved toward the center of the pupil. Once one sector of
cortex is removed, an adjacent portion usually becomes available for easy purchase and removal. This procedure is repeated until the entire cortex is removed. (2), (7)

**Irrigation/aspiration (I/A):**

*Irrigation/Aspiration tips:* are available in many different port diameters, from 0.2 to 0.7 mm; however, 0.3 mm is most commonly used. As a general rule for 0.3-mm I/A tips, 100 to 150 mmHg vacuum is sufficient to hold the cortex for stripping while levels of 350 to 400 mmHg will aspirate the cortex through the port. (7), (17)

*a) Manual I/A:*

Many surgeons prefer to use a manual system such as the Simcoe cannula to aspirate the cortex. This method is useful because it provides the surgeon added security through manual control of the aspiration dynamics. (2), (7)

*b) Automated I/A:*

**1- Straight tip**

The standard automated I/A handpiece is equipped with a straight, blunt-end tip with a 0.3 mm aperture for aspiration on its anterior surface. This tip works well for cortical removal from the 180 degrees of the capsular bag most distal to the incision site.
However, as the surgeon progresses closer to the subincisional cortex, obtaining an adequate purchase of the cortex becomes increasingly more difficult. Furthermore, the possibility of tearing the posterior capsule increases as the port is turned more posteriorly in an attempt to engage the subincisional cortex. (2) (7)

2- Curved tips:

Several manufacturers are now offering I/A handpieces with interchangeable curved aspiration tips. The most commonly available tips include angles of 30, 45, 90, and 180 degrees. These angled tips allow easier access into the capsular bag and facilitate the purchase of subincisional cortex. (2), (7)

Bimanual automated I/A:

One of the newer techniques for cortical removal involves the use of separated ports for irrigation and aspiration. The main wound, if constructed properly, is self-sealing when the pressure is increased in the anterior chamber. This system allows easy access to all areas of the capsular bag for safe removal of the cortical remnants but requires bimanual dexterity and forces the surgeon to be cognizant of the location of two instruments simultaneously in the eye. (2), (7)
Subincisional cortex:

The removal of the subincisional cortex is often the most difficult and stressful aspect of cortical cleanup for the cataract surgeon. There are multiple methods that can be used successfully. Some of the more commonly employed techniques include:

1- using the straight I/A tip with the port turned more posteriorly to engage the cortex.

3- using an angled I/A tips.

4- using the manual I/A tip (Simcoe) through an enlarged paracentesis.

5- using a bimanual automated I/A technique. (2), (7)

Capsular polishing and vacuuming:

Occasionally, following successful cortical cleanup, a plaque or strands of cortex may remain on the posterior capsule. If these remnants are in the visual axis, they can affect postoperative visual acuity. These remnants, especially those that contain epithelial cells, can also contribute to postoperative posterior capsular opacification. By performing capsular polishing or vacuuming one can make a good surgical result even better. Vacuuming involves combining relatively low flow rates (0.5 mL/min) with low vacuum
rates (approximately 5 mmHg) to dislodge and suck the cortical bits into the I/A tip. Many of the newer phacoemulsification machines have preset values already programmed into the machine’s software to make this function faster and less personnel dependent. At appropriate settings, the formation of a 3 - 4 mm “spider” pattern on the posterior capsule should be seen. If the “spider legs” get too long, traction on the capsule is excessive and the incarcerated capsule should be released immediately. (2), (18)

4-LASER PHACOLYSIS:

Inspite of the advantages of phaco systems, there are tow problems not solved, one is the posterior capsular opacity, while the other is loss of accommodation after implantation of IOL in a very successful surgery. Laser phaco ablation is an advance in cataract surgery, which has advantages over phacoemulsification; there is less thermal burn after wound, safer to the endothelium, decreased risk of posterior capsular damage and the small capsulorrhexis allows refilling of the bag by silicone, so restores accommodation. But in term of efficacy, laser is less because it is unable to remove dense nuclei, takes longer time and the machine is very expensive.
Erbium; YAG and Neodymium; YAG lasers are available for phacolysis in some developed countries. (11), (19)

5- CLEAR LENS EXTRACTION:

In patients with high myopia or high hyperopia, extraction of the lens and replacement by a very low (or minus) or high power IOLs, respectively, may improve their refractive errors better than corneal keratoplasty, with respect to complication of cataract surgery. (11)
COMPLICATIONS OF CATARACT SURGERY:

A) INTRAOPERATIVE COMPLICATIONS:

1- Expulsive choroidal haemorrhage:

The complication to be most feared in cataract surgery is that of an expulsive choroidal hemorrhage. Risk factors in developing this complication include axial length greater than or equal to 25.8 mm, a history of glaucoma, preoperative intraocular pressure of 18 mmHg, obesity, anticoagulants drugs, chronic ocular inflammation and intraoperative pulse greater than or equal to 85 beats per minute. (2), (20), (21)

2- Suprachoroidal effusion or haemorrhage:

Present as forward displacement of posterior ocular structures including iris and vitreous, accompanied by a change in the red reflex. It has same risk factors and management of expulsive haemorrhage. (2), (20), (21)

3- Choroidal detachment:

Detachment of the choroid, often including the pars plana of the ciliary body, may follow a wound leak. The onset of choroidal detachment usually is 1 or 2 weeks following surgery, and the entire course usually is no longer than 1 to 2 weeks. (2), (7), (21)
4- **Retrobulbar haemorrhage:**

   The anaesthetic needle perforating one of the many vessels that traverse the posterior orbit causes a retrobulbar hemorrhage. (2), (21)

5- **Posterior capsular rupture:**

   Posterior capsule rupture occurs in 2% to 5% of patients, and if dealt with properly, the visual result is usually good. The incidence in ordinary ECCE with IOL is comparable phaco. The tears occur most frequently during nucleus removal and posterior capsule vacuuming. (2), (22), (23), (24)

6- **Peripheral extension of capsulorrhexis:**

   One of the most common problems encountered during the capsulorrhexis is peripheral extension. Positive vitreous pressure with anterior bowing of the lens frequently promotes peripheral extensions; therefore, use of sufficient viscoelastic to deepen the anterior chamber and flatten the anterior capsule is helpful. (2)

7- **Zonular dialysis:**

   Several conditions including prior ocular trauma, pseudoexfoliation syndrome, Marfan’s syndrome, homocystinuria, and Weill-Marchesani syndrome, are associated with weakened or
torn zonules. Zonular dialysis can occur during routine phacoemulsification surgery from excessive nuclear manipulation, aspiration and traction on the capsular bag during I/A, or stress on the bag during IOL insertion. (2)

8- The “dropped” nucleus:

The loss of nuclear lens fragments into the posterior segment through a tear in the posterior capsule can cause chronic and recurrent uveitis unless it is removed. (2), (7), (25)

9- Tear in Descemet’s membrane:

Descemet’s membrane is susceptible to tearing at the wound’s internal entry site and at the site of stab incisions. Tears commonly present as clear, anteriorly scrolled segments of Descemet’s membrane and may be mistaken for small pieces of cortex near the wound. (2), (26)

10- Thermal Burn:

A portion of the energy produced by the phacoemulsification tip is converted to heat. This heat is normally dissipated and the anterior segment spared injury by the constant flow of balanced salt solution. However, only several seconds of interrupted flow into the eye is sufficient to produce a corneoscleral burn. Thermal burns
cause tissue shrinkage and may require multiple sutures to close
the wound. Failure to adequately close the wound may increase the
risk of postoperative infection or lead to astigmatism and an
inadvertent filtering bleb. \(^{(2)}\), \(^{(7)}\), \(^{(21)}\)

11-Retinal Light Toxicity:

Prolonged exposure to the illuminating filament of the
operating microscope can result in increased risk of CME or burn to
the retinal pigment epithelium RPE, due to exposure to UV light. \(^{(21)}\)

B) POSTOPERATIVE COMPLICATIONS:

Occasionally, despite a flawless and technically uneventful
surgery, the patient may experience complications in the
postoperative recovery period. These can generally be considered
in two categories, those that occur in the short term (first 6 weeks)
and those that occur in the long term (greater than 6 weeks). \(^{(7)}\)

1-Short-term complications:

1-1 Postoperative inflammation:

A small degree of postoperative intraocular inflammation is to
be expected even after uncomplicated phacoemulsification cataract
surgery. The inflammation is limited to the anterior chamber and
responds to topical corticosteroids with resolution over several days
to weeks. Postoperative inflammation may be more pronounced if the surgical time was prolonged or there was excessive manipulation of the iris, posterior capsular rupture, or vitrectomy performed.\(^7\)\(^{27}\)

**2-1 Wound Dehiscence:**

The estimated incidence of wound dehiscence of between 1% and 5% has likely declined in recent years because of the shift toward small-incision surgery. Wound dehiscence can occur spontaneously as a result of poor wound closure or secondary to trauma such as the patient rubbing the eye. The critical elements that affect wound dehiscence are wound construction and wound closure. Creation of a true, triplanar self-sealing scleral tunnel incision minimizes the risk of wound dehiscence. Active wound healing begins within 48 hours of surgery. At one week postoperatively, wound strength is approximately 10% of that present in normal tissue. By 8\(^{th}\) week, wound strength has improved to 40% and at 2 years the wound has regained approximately 75% to 80% of its preoperative strength. Patients at risk for development of wound dehiscence include those who are malnourished (especially vitamin C and protein deficient), those with Werner's
syndrome, those with peripheral ulcerative keratitis or scleritis associated with systemic collagen vascular disease, and those treated with high-dose systemic steroids. Wound dehiscence may manifest as a wound leak, an inadvertent filtering bleb or complete wound rupture. The clinical signs associated with wound leak include poor vision, hypotony, a shallow anterior chamber, hyphaema, choroidal folds or effusions, and optic nerve edema. A wound leak may be identified by painting the suspicious area with a fluorescein strip and viewing with light passed through a cobalt blue filter (Seidel test). (2), (7), (11)

3-1 Postoperative ocular hypertension:

An acute rise in intraocular pressure (IOP) is not infrequent following phacoemulsification surgery combined with the use of viscoelastics. Viscoelastic that remains within the anterior chamber hydrates and swells, occluding the trabecular meshwork and impeding the normal outflow of aqueous. (28) A certain percentage of patients are “steroid responsive” and will manifest elevated IOP in response to topical steroids. Infrequent causes of postoperative ocular hypertension or glaucoma include: hyphaema, uveitis, lens particle glaucoma, aqueous misdirection (malignant glaucoma),
cyclodialysis cleft closure, neovascular glaucoma, and epithelial or fibrous downgrowth. (2), (7)

4-1 Vitreous prolapse:

Vitreous prolapse into the anterior chamber is infrequent following uneventful phacoemulsification surgery with placement of a posterior chamber IOL. However, in the setting of zonular dialysis or posterior capsular rupture, the vitreous body can prolapse forward, extending to the wound or causing pupillary block. Vitreous incarceration in the wound (vitreous wick syndrome) is associated with astigmatism, cystoid macular oedema and endophthalmitis. (7), (29)

5-1 Flat anterior chamber:

A flat anterior chamber is another finding associated with wound leak. The flat anterior chamber associated with hypotony may require exploration and resuturing of the limbal incision. (2), (11)

6-1 Pupillary block:

Pupillary block is another cause of a flat anterior chamber in the early postoperative period, but in this case, unlike a flat anterior chamber associated with wound leak, intraocular pressure is usually
elevated. Commonly the intact anterior hyaloid face of the vitreous plugs the pupillary opening as well as iridectomy openings.\(^{(2)}\), \(^{(11)}\)

7-1 **Corneal oedema:**

The overall incidence is less than 1%. Damage to the endothelium can occur from a number of different insults. Surgical trauma, Preexisting disease such as Fuchs’ dystrophy or unrecognized low endothelial cell count without guttae can predispose a patient to development of corneal oedema. Inadvertent administration of toxic substances such as improperly formulated antibiotics (especially Aminoglycosides or Vancomycin) can damage the endothelium causing corneal edema.\(^{(7)}\)

8-1 **Haemorrhage:**

Some hemorrhage may remain following the operative procedure, but occasionally new hemorrhage accumulates in the anterior chamber following surgery. Nevertheless, postoperative hemorrhage usually resolves spontaneously without treatment.\(^{(2)}\), \(^{(7)}\).\(^{(11)}\)
2- LONG TERM COMPLICATIONS:

1-2 Cystoid macular oedema:

Cystoid macular edema remains one of the most frustrating situations of all for both patient and ophthalmologist. Usually, the patient's spirits have been lifted by a seemingly good result for several months following surgery when, unexplainably, central visual acuity drops, often to the level of 20/200. Although this condition is sometimes associated with vitreous loss, it occurs frequently enough in uncomplicated cases. \(^{(2), (7), (9), (13)}\)

2-2 Endophthalmitis:

Inflammation of intraocular tissues can occur following surgical trauma, in response to inadvertent instillation of irritating substances into the eye and secondary to the introduction of microorganisms at the time of surgery. The course of bacterial endophthalmitis often runs over a period of only 1 or 2 days before visual function is destroyed, so prompt action is absolutely essential if anything useful is to be salvaged. \(^{(2), (7)}\) Endophthalmitis incidence is lesser after phaco (0.57%) than ECCE (1.13%). \(^{(30)}\)
3-2 Iris prolapse:

Iris prolapse is a manifestation of wound failure. If it occurs early in the postoperative course, the wound should be explored, and resuturing performed. If the iris is prolapsed less than 96 hours, it may be reposited. Other treatment options include surgical excision, photocoagulation, cryotherapy, or chemical cautery. The late occurrence of iris prolapse does not necessarily require surgical repair, and, indeed, this may be difficult to perform if attempted.\(^{(2)}\) There may be a persisting unpleasantly high astigmatic element.\(^{(12)}\)

4-2 Epithelial invasion of the anterior chamber:

Epithelial invasion of the anterior chamber is another manifestation of inadequate wound closure. Epithelium has a tendency to cover unopposed raw wound surfaces in a few days. Three morphologic growth patterns have been described:

1) “Pearl” tumors of the iris.
2) Epithelial inclusion cysts.
3) Sheet-like epithelial ingrowth.\(^{(2)}\)

5-2 Retinal Detachment:

Retinal detachment following cataract surgery occurs in 1% to 2% of cases in most series that have been reported. With current
phacoemulsification techniques, the incidence is approximately 0.75–0.9%. (2), (11)

6-2 Posterior capsule opacification (PCO):

Opacification of the posterior capsule is a relatively common event following successful cataract surgery. Retained epithelial cells in the peripheral lens equator proliferate and migrate posteriorly, wrinkling and/or forming a thin plaque along the posterior capsule, thereby degrading the retinal image. The incidence is approximately 30% to 40% by 2 years after surgery. (2), (11), (31)

7-2 Dislocated lens implant:

Posterior chamber lenses may dislocate so that the upper equator of the implant appears within the pupillary space and gradually moves down. Often called the sunset syndrome, this phenomenon usually is the result of loss of support of the inferior haptic because of a rupture of the inferior capsule or zonules. Due to lens power affectivity, this will shift the patient's refractive error toward myopia with degree of astigmatism. (7), (11)
8-2 Iris Tuck:

Iris tuck, which is entrapment of the peripheral iris between the implant and adjacent angle structures, is a significant complication of anterior chamber IOL implantation. (2)

9-2 Macular infarction:

Due to subconjunctival injection of Aminoglycosides, especially Gentamicin, intraoperatively. (11)

Other complications:

10-2 Chronic Uveitis.

11-2 Corneal Melting.

12-2 Iridodialysis.

13-2 Cyclodialysis.

14-2 Ciliary Block Glaucoma; Malignant Glaucoma. (11)
Intraocular Lenses

HISTORY:

The concept of an IOL was proposed and allegedly attempted in the 18th century. However, the modern era of IOL implantation was a by-product of World War II technology. Harold Ridley, then on active duty, noted that when Perspex (PMMA) was involved in traumatic injuries to the eye, there was good intraocular tolerance to this foreign body. Ridley used this material to fabricate a posterior IOL, which he implanted in London in November 1949. Epstein modified the Ridley lens several times. Baron selected the anterior chamber for IOL insertion and implanted such a lens in May of 1952, whereupon several surgeons took up this type of implant surgery. (2), (11)

Current IOL history belongs to the posterior chamber IOL, which is evolving in optic design that includes not only configuration but also bifocal and multifocal innovations. New materials are being sought to produce the ideal foldable lens for small incision surgery, the stimulus being to make the surgery as atraumatic as possible with the fastest rehabilitation. (2), (11)
INTRAOCULAR MATERIALS:

1- Polymethylmethacrylate (PMMA):

It was fortuitous that Ridley selected this material because it has been in continuous use for over 40 years without any reported cases of intraocular degradation and is the benchmark against which any other material must be compared. (2), (11)

2- Foldable acrylic material:

It has a refractive index of 1.48, which comes quite close to that of PMMA. Moreover, the material has a good optical and mechanical memory, returning to its desired shape and dioptic power rapidly, although dependent on ambient temperature. (2), (7), (11)

3- Polypropylene:

Polypropylene is widely used in IOLs as a haptic loop material in the posterior chamber and was formerly used, to a much lesser degree, in the anterior chamber. (2)

4- Glass

Glass offered great promise for intraocular lens fabrication because it could be heat sterilized and is of a higher refractive index than PMMA. Regrettably, glass shatters under the impact of the
neodymium: yttrium-aluminum-garnet (Nd: YAG) laser, and the clinical use of glass lenses has been abandoned. \(^{(2)}\)

4- Silicone:

Silicone's resistance to heat is a dubious advantage. More significant is silicone's amenability to folding. The disadvantages of silicone include a refractive index (1.46.) inferior to PMMA. Consequently, silicone IOLs of higher dioptric powers, as presently designed, may be bulky for small-incision insertion. Some surgeons have also complained that an Nd: YAG posterior capsulotomy is more difficult with a silicone IOL. Without question, when gas-fluid exchange techniques are used in posterior segment surgical procedures, there is a gas-silicone interface, which obscures visualization and persists until the gas absorbs. \(^{(2)}, (11)\)

5- Hydrogels:

The hydrogels are hydrophilic, permeable, biocompatible, and heat sterilizable. Unfortunately, they also have a low refractive index (1.43), and their usage in customary dioptric powers as a foldable IOL is moot. Moreover, they have been shown to torque and dislocate intraocularly. \(^{(2)}, (7)\)
CONTEMPORARY LENS IMPLANTATION

Posteriorchamber intraocular lenses:

Those models fixated in the posterior chamber dominate the current usage of IOLs. There is substantial difference in design and long-term intraocular tolerance among anterior chamber, iris-fixated, and posterior chamber IOLs produced by fixation site, fixation means, and optic position. (2), (31)

Anterior chamber intraocular lenses:

An anterior chamber IOL fixates in the anterior chamber with its footplates resting in the angle structure. (32)

Clinical investigation shows unsatisfactory postoperative results. PMMA loops have been associated with fibrosis in the angle and late rise in intraocular pressure. (33)

Bifocal and multifocal posterior chamber intraocular lenses:

All implanted IOLs had been unifocal until 1986 when the first multifocal posterior chamber IOL was implanted in a cataract patient in England. (34) These initial implantations were with posterior chamber IOLs having two concentric refractive optical zones, a design reminiscent of a type of bifocal contact lens wherein the
inner zone focused at near and the outer surrounding zone at distance.

There is a theoretic reduction in contrast by as much as 50%. The loss of contrast, however, does not appear to be clinically significant over a vast majority of patients.\textsuperscript{(2), (11)}
ASTIGMATISM

Is that condition of refraction wherein appoint focus of light cannot be formed upon the retina. \(^{(35)}\)

**Aetiology:**

Astigmatism may be an error either of curvature, of centering or of refractive index.

1) **Curvature astigmatism:** Has its seat most frequently in the cornea and is usually congenital. Its occurrence in small degrees is almost invariable. The direct astigmatism, wherein the vertical curvature is greater than the horizontal (about 0.25D), is accepted as physiological. It may be due to constant pressure of the upper lid upon the eye. When the horizontal curvature is greater, the astigmatism is indirect, in other terms with the rule for the former and against the rule for the later. Acquired curvature astigmatism is not infrequently seen. Diseases of the cornea result in its deformity; such as conical cornea, inflammations & ulcerations produce astigmatism. Trauma including surgery, particularly cataract operations, is another cause. Further more, corneal astigmatism can be induced by pressure swelling of the eyelid. Curvature astigmatism of the lens also occurs with great frequency. In the
great majority of cases such anomalies are small; but on occasions, as in lenticiconus, they may be marked. (35)

2) **Decentrile**: The lens may be placed slightly obliquely or out of line in the optical system, and thus, causing a corresponding astigmatism. Traumatic subluxation of the lens has similar results. (35)

3) **Index astigmatism**: A small amount of index astigmatism occurs physiologically in the lens, due to small inequalities in the refractive index of the different sectors, but may be accentuated to produce considerable distortion or even polyopia in the grosser change of cataract. (35)

**Types of astigmatism:**

1) **Regular astigmatism**: Where the two principal meridians are at right angles. In the great majority, the meridians of greater and least curvature are close to or actually vertical and horizontal, or vice versa. Oblique astigmatism occurs when the least and greatest meridians are not at right angles. The optical system in both conditions is still resolvable into sphero-cylindrical combination. Regular astigmatism can be classified into:
1-1: **Simple astigmatism**: In which one meridian is emmetropic while the other is either myopic or hypermetropic. They are respectively designated simple myopic and simple hypermetropic astigmatism.

1-2: **Compound astigmatism**: Both meridians are ametropic but with the same sign and the state of refraction either compound myopic or compound hypermetropic astigmatism.

1-3: **Mixed astigmatism**: One meridian focuses light in front of and the other behind the retina, so the refraction is myopic in one meridian and hypermetropic in the other.\(^{(35)}\)

**Irregular astigmatism**: The refraction in different meridians is quite irregular. A small degree may occur physiologically. A marked degree of irregular astigmatism is seen in corneal deformity due to scarring and opacities results from trauma, inflammation or ulceration of the cornea. It is also seen in lenticonus and keratoconus.\(^{(35)}\)

**Measurements:**

1-**Manual or automated Keratometer:**

It measures the corneal curvature in central 2-3 mm of the anterior corneal surface, by projecting two vertical and two
horizontal points. The readings may not be accurate, because the peripheral cornea is ignored, the axes may not be 90 degrees to each other and mild irregularities can cause mire distortion. So, it is better to combine it with corneal topography in measuring pre or postoperative astigmatism. It is more useful in IOL power calculation and contact lens fitting.\(^{(36)}\)

2- **Corneal topography:**

With videokeratoscopy provides a colour-coded map of the corneal surface. The dioptric power of the steepest and flattest meridia and their power also calculated and displayed. The machine is more accurate than keratometer and is used to quantify irregular astigmatism, diagnose early keratoconus and after refractive surgery, corneal grafting or cataract surgery. The disadvantage, it is rather expensive.

It has two scales:

1- Absolute scale: useful in comparing between different individuals.

2- Relative (normalized) scale: has no fixed end-points, used in comparing different parts of the same cornea.\(^{(36)}\)
Other methods:

3- Corneal Topography (Computerized Video Keratography).
4- Van Loenen Keratoscope.
5- Corneoscope.
6- Terry Keratometer: can be used intraoperatively. \(^{(7)}\), \(^{(37)}\)

Preoperative astigmatism:

Preoperative astigmatism has predictive value for postoperative astigmatism. Talamo et al. showed that in those patients who have 0-2D of preoperative WTR astigmatism, the average 2-year postoperative astigmatism was 1.18D ATR. Those who have >2D WTR astigmatism before surgery had on average 1.2D WTR astigmatism 2 years postoperatively. Therefore, patients tended to have less postoperative WTR than preoperative WTR astigmatism. Preoperative ATR astigmatism showed the opposite trend. Those who have 0-2D of ATR astigmatism had 1.47D of WTR astigmatism on average, while greater than 2D of preoperative ATR astigmatism was associated with 2.25D ATR astigmatism at 2 years postoperatively. These results imply that the cornea tends toward the original magnitude and direction of the initial astigmatism, except when more than 2D of ATR astigmatism exists.
preoperatively. Patients with preexisting WTR astigmatism may get benefit from sutureless surgery, while patients with preexisting ATR astigmatism may get benefit from sutured incision.\(^{38}\)

**Postoperative astigmatism (P.O.A):**

Even with modern microsurgical methods astigmatism has not been eliminated. The factors concerned in the genesis of this astigmatism are multiple and not completely understood.\(^{39}\) The amount and stability of corneal flattening is dependent on the incisional design and location, the use of cautery, sutures, and corticosteroids, and the length of time since the surgery. Wound compression by sutures and cautery initially tends to steepen the cornea in the meridian of the incision, with a gradual relaxation over time.\(^{3}\)

Appreciation of the physical dynamics of the cornea is key to understanding surgically induced astigmatism. Jaffe and Clayman's found that the steepness of the corneal meridian was related to suture knot placement; Cravy emphasized that total central corneal power is conserved in cataract surgery, not decreased or increased, as long as tissue is neither added nor removed. These initial
observations provided the foundation for better insight into corneal biomechanics.

Using a corneoscope (an early form of Placido disc imagery), Rowsey established the principles that govern our ability to understand refractive power changes and coupling in the cornea. The first six of the ten 'caveats' are listed here, as they are most applicable to the dynamics encountered in cataract surgery:

• the normal cornea flattens over any incision.
• radial corneal incisions flatten the adjacent cornea and the cornea 90° away.
• the flattening effect of radial incisions on the cornea increases as incisions approach the visual axis.
• the cornea flattens directly over any sutured incision.
• the cornea flattens adjacent to loose limbal sutures, flattens 180° away, and steepens 90° away.
• the cornea steepens adjacent to tight limbal sutures, steepens 180° away, and flattens 90° away. (7)
Factors affecting postoperative astigmatism:

1- The size of incision: Small incision cataract surgery and phacoamulsification, lead to more rapid stability of the pseudophakic refraction, though the degree of astigmatism may be only marginally better than after large incision cataract surgery. But in some studies they found that, these long incisions can induce initial large amounts of with-the-rule (WTR) astigmatism. Mean dioptric initial WTR astigmatism can be 3.4D (range 1.7-4.7) at 1 week, and 2.0D (range, 1.0-3.0) at 12 weeks, which does not differ from preoperative astigmatism. Neumann et al reported aggregate surgically induced astigmatism of 1.29D at 3 months and 1.08D at 6 months. Talamo et al analyzed the 2-year postoperative trend by category and found 1.48D of WTR astigmatism at 1 month, 0.29D of against the rule (ATR) astigmatism at 6 months, 0.76D of ATR astigmatism at 12 months, 1.15D of ATR astigmatism at 24 months, 1.19D of ATR astigmatism at 36 months, and 1.23D of ATR astigmatism at 48 months. Lindstrom and Destro showed that in a group of patients who had 6.5 mm incision phacoemulsification, only 5% had greater than 3D and 65% less than 1D of astigmatism at 6-10 weeks.
postoperatively. This compared favourably to 24% with greater than 3D and 27% with less than 1D of astigmatism in the 10 mm NE (Nucleus Expression) group.\(^{(37)}\) The longer incision and increased number of sutures in NE undoubtedly results in the greater degree of astigmatism.\(^{(40)}\) However, in phaco VA is markedly better, in the first postoperative period, than large incision ECCE.\(^{(41), (42), (43)}\)

The shape of incision has its effect on postoperative astigmatism and stability of the wound. Frown and straight incisions are more astigmatically neutral and wound stable.\(^{(44), (45)}\)

2- The site of incision:

A- Scleral tunnel incision:

The scleral tunnel incision is a two or tri-planed incision that begins in the sclera and has a relatively long course, entering the anterior chamber through the peripheral cornea. It was favoured for many years as an effective incision for phaco, but it is no longer the incision of choice. This incision was designed:

(1) to reduce postoperative astigmatism by virtue of its relatively long scleral course. Furthermore more posterior incision is believed to be more stable as it minimizes any 'slip' the cornea may experience from a more anterior (closer to the limbus) incision.\(^{(46)}\)
Posterior incisions benefit from greater scleral support, which counters wound slippage.\textsuperscript{(7)}

(2) To enter the anterior chamber distal to the iris root to minimize the potential for iris prolapse during phaco. \textsuperscript{(16)} This incision requires either radial, horizontal suture closure or may be sutureless. \textsuperscript{(2), (47)}

**Scleral tunnel with internal corneal lip incision:**

The scleral tunnel with internal corneal lip incision, a modification of the conventional scleral tunnel incision affords the beginning phaco surgeon an excellent comfort level in initiating the procedure, and if mastered, it will permit excellent control during the operation. Also, the corneal lip decreases the incidence of iris prolapse. \textsuperscript{(47)} The following are characteristics of scleral incisions that promote wound stability:

1- the incision should be contained within an incisional funnel. Incisions that reside within this funnel are associated with wound stability.

2- making an internal corneal lip that is appositionally closed when the eye is repressurized creates a self-sealing incision that virtually eliminates the need for suture closure.
3- Similarly, a curved incision, with its convexity toward the cornea, possesses incisional stability because it is entirely within the funnel.

4- The rich blood supply insures rapid and good healing. \(^{(2)}\)

**B- Corneal incision:**

The corneal incision for phaco and implantation of foldable IOLs has recently commanded interest. The primary advocates of this incision in combination with phaco are Shimizu and Fine. When Fine began using foldable IOLs in patients who had preexisting filtering blebs, he noted that his use of clear-corneal incisions led to rapid visual rehabilitation. Initially, he closed these incisions with two radial sutures; he later modified the incisions, making them longer and closing them with a single horizontal suture. Finally, he developed a beveled, single-planed, self-sealing incision; the temporal clear-corneal incision.

The proposed advantages of a temporal clear-corneal incision are as follows:

1- Better accessibility because brow obstruction is eliminated

2- Better red reflex.
3- Elimination of the conjunctival incision and preservation of conjunctiva for filtering surgery in eyes with glaucoma.

4- Elimination of hyphaema.

5- Reduced postoperative astigmatism because the effects of gravity are minimized and the effect of eye lid blinking on the incision is neutralized. \(^{(2)}\)

**C- Limbal incision:**

It has four advantages over true corneal incision:

- First, wounds located in the limbus are 30-100% stronger than those just 0.5 mm anterior to it. This because the lamellar arrangement resembles a meshwork which give the limbus more stable wounds.

- Secondly, limbal incision is so much closer to vascular supply, so it heals much more quickly.

- Thirdly, patients are more comfortable with limbal incision, because there is no foreign body sensation felt in corneal incision.

- Fourth, topography and refraction are stable up to 4 mm without sutures, compared with 3 mm in clear corneal incision. \(^{(2)}\)
3- Suture material:

Suture selection in cataract surgery remains the subject of intense controversy. The only area of general agreement has been the increasing tendency for sutures of smaller diameter. Suture materials contribute to varying amounts of astigmatism based on their elasticity and production of tissue reaction. Generally, inelastic sutures producing minimal tissue reaction create the least amount of astigmatism. Silk is less elastic than nylon, but it induces more tissue reaction. Polypropylene and Mersilene are less elastic and produce less tissue response than nylon; however, they are more difficult to tie. Regardless, it is suture placement and tying that contribute more to astigmatism than suture type.\(^{(2), (48)}\)

Sutures may be placed and tied in either an interrupted or continuous running fashion. Interrupted sutures offer the advantage of more tension control for each bite, more wound security, selective suture removal postoperatively and the ability to rotate and bury knots. The running suture technique offers the advantage of speed and more equal distribution of tension, which may decrease astigmatism. The running suture technique most commonly used is
the shoe-lace suture. A compromise between these two suture techniques is intermingling "X" sutures with interrupted sutures.

When interrupted sutures are used to close a 160° incision, an average of seven or eight sutures are usually needed, ranging from five to ten sutures. The exact number is not important, but at the end of the procedure the wound should be secure without evidence of leakage when the intraocular pressure has been restored with balanced salt solution. But in some studies a 7 mm long scleral pocket incision causes more postoperative keratometric cylinder than a 4mm wound (1.33D and 1.03D, respectively) up to 6 weeks postoperatively. Phacoemulsification procedures require even fewer sutures, and perhaps even no sutures. Incisions through which foldable lens implants are inserted are only 4 mm wide and may be closed with a single horizontal suture through the scleral groove, hence the marketable term "one-stitch cataract surgery." Some surgeons feel that if the scleral groove is adequately long (4 mm), the groove may seal itself and no suture would be necessary, hence we have "no-stitch cataract surgery." A suture that is tied too tightly can produce distortion of the cornea with resultant astigmatism. The astigmatism tends to be correctable by a plus
cylinder in the axis of the offending suture. Long sutures are felt to induce more steepening (with the incision) than short bites, because of the greater forces needed to secure the former. For a given incision that can be closed adequately with a certain number of short sutures, fewer long sutures are required to close the same wound because the greater vector forces generated by each long suture oppose a wider amount of tissue margins. (7)

Approximately 3 D of with-the-rule astigmatism should be the goal intraoperatively, since healing gradually shifts toward against-the-rule astigmatism. (2) Until recently, the time at which to cut sutures after nuclear expression (NE) extracapsular cataract extraction had been traditionally more of an art. Talamo et al. determined a monthly decay rate of 0.05D toward ATR astigmatism for a 24-month period based on 77 patients who had no suture cutting. (38) For patients who had less than 2D of WTR astigmatism at 1 month postoperatively, the mean ATR astigmatism was in the range 1.13-1.61D at 24 months. Whereas those who had 2-3D WTR astigmatism at 1 month had on average 0.25D WTR astigmatism at 2 years postoperatively. Based on these results, the authors recommend:
1) Aiming for 2-3D of WTR astigmatism at 1 month, and
2) If significantly more than 3D of WTR astigmatism is present at 3-5 weeks, sutures may be cut at the 8-10 week gate.
3) Other authors have recommended suture removal at 12 weeks postoperatively and prescribing glasses 1 month after suture removal. Beware that suture cutting may turn WTR astigmatism into unwanted ATR astigmatism over time.\(^{(50)},(51)\)

4- **Eccentricity of the implanted lens**: or its tilt has remarkably small effect on the total astigmatism of the eye. This may be due to the small difference of refractive index between the implant material (1.49) and that of the medium on either side (1.336). This is unless the IOL is markedly subluxated or dislocated.\(^{(35)}\)

5- **Postoperative Corticosteroids:**

   While corticosteroids only equivocally affect corneal epithelium healing, they may inhibit fibroblastic activity in the stroma and sclera. Manipulation of the duration of action of corticosteroids has been advocated to tailor the postoperative course to a desired astigmatic endpoint. Prolonged use of corticosteroids in selected
cases may allow greater wound slippage to help treat pre-existing WTR astigmatism. Likewise, a short course of postoperative corticosteroids may help to minimize astigmatic decay from a superior scleral pocket incision in a patient who has preoperative ATR astigmatism.\(^7\)

**Management of astigmatism:**

**Calculation of surgically induced astigmatism (SIA):**

To use postoperative astigmatism as the only quality parameter of incisional and suture techniques would make interpretation difficult. To estimate the true effect of cataract surgery on corneal curvature, the surgically induced difference between pre- and postoperative keratometric readings must be calculated. Cravy pointed out that collection and analysis of pre- and postoperative keratometric data could help the surgeon to predict the type of corneal astigmatism in subsequent cases, and forewarn that the usual incision, if used in a particular patient, could result in an optical disaster. Conventional keratometry and videokeratography both are used to evaluate surgically induced refractive changes in the cornea. Conventional keratometric measurements are made at the central 3 mm of the cornea where the orthogonal meridional
power automatically is assumed to the flattest, to determine the power of the steepest meridian. Videokeratography additionally evaluates and detects irregularities over the entire corneal surface.

Several methods based on keratometric measurements of regular astigmatism are available to quantify and compare surgically induced astigmatism (SIA) in individuals, in subgroups of patients, and at different intervals after cataract surgery. The formulae include simple subtraction, algebraic method, polar analysis (Naeser), trigonometric polar analysis (Cravy), vector analysis (Jaffe), vector decomposition (Olsen), and multivariate probability-based analysis (Toulemont).\(^{(52)}\)

**a) Simple subtraction:**

The easiest way to calculate SIA is subtraction of the power of astigmatism before (A preop) from that after surgery (B postop), regardless of axis before (a preop) and after (b postop):

\[
\text{SIA subtraction} = B \text{ postop} - A \text{ preop}
\]

This method is only correct when the axis is the same before and after surgery (a preop = b postop). It can be used by a trained observer as a fast way to obtain an idea of the refractive result in individual cases, especially when the change in axis is minimal.\(^{(52)}\)
b) Algebraic method:

Based on the direction of the steep axis or the plus cylinder, astigmatism is divided into either, with-the-rule (WTR) astigmatism (45° < axis < 135°), or against-the-rule (ATR) astigmatism (135° < axis < 180°; 0° < axis < 45°)

With these definitions, if either axis, a preop or b postop is ATR, the respective power is multiplied by –1. This method gives the best results when the pre- and postoperative axes are close to either the vertical and/or the horizontal meridians.

• Equation

\[ \text{SIA algebraic} = B \text{ postop} - A \text{ preop}. \] \(^{(52)}\)

c) Polar values:

With this method astigmatism is conceived as a cylinder projected in a three-dimensional coordinate system. By optical decomposition of the polar coordinates of astigmatism (amplitude A, axis a) onto the 90° and 180° meridians, its net WTR (+) and ATR (-) components are expressed. To calculate SIA the preoperative is subtracted from the postoperative polar value;

\[ \text{SIA pol} = B \text{ pol} - A \text{ pol} \]

\[ = B \cos 2b - A \cos 2a. \] \(^{(52)}\)
d) Trigonometric polar method (Cravy):

The polar coordinates of astigmatism measured by keratometry pre- and postoperatively (amplitude A, axis $a$ and amplitude B, axis $b$) are projected on the x-axis as $xa = A \cos a$ and $xb = B \cos b$, and on the y-axis as $ya = A \sin a$ and $yb = B \sin b$. When the axis difference between the two astigmatisms is greater than $90^\circ$, then $180^\circ$ should be added to or subtracted from one of them.

The difference on the x-axis is $D(x) = B \cos b - A \cos a$; and the difference on the y-axis is $D(y) = B \sin b - A \sin a$. These differences are changed to absolute values before they are added to give the total induced astigmatism (TIA), equation. By introducing the sign convention, it is possible to express SIA as either WTR or ATR.

• Equation

$TIA \text{ Cravy} = absx |(B \cos b - A \cos a)|absy |(B \sin b - A \sin a)|$

$= absx |xb - xa| + absy |yb - ya|$

$= D(x) + D(y)$

Surgically induced astigmatisms (SIAs) calculated from polar values and Cravy’s method deal with the axial dependency of the induced cylinder. A disadvantage is that any astigmatism induced at
or close to 45° or 135° gives results close or equal to zero; these methods therefore, like the algebraic method, give the best results in the vertical and horizontal meridians. (52)

e) Vector analysis:

The vector method provides an easy analysis of surgically induced refractive changes or SIA in a single cataract patient who has oblique pre- and postoperative astigmatisms, but to analyze multiple cataract cases over a period of time the problems are different. (52)

f) Vector decomposition and coupling:

Another way to attack the change in direction of SIA is to decompose each induced vector into its vertical and horizontal components, and calculate the percentage change in each of these directions (Vector decomposition). The law of elastic domes states that for every change in curvature in one meridian, there is an even and opposite change 90° away. The total amount of astigmatism corrected is equal to the sum of the changes in the plane of the incision and 90° from it (coupling). (52)
g) **Multivariate probability-based method:**

This is a purely mathematic method, that uses computation simply of keratometric changes in a contingency table (deltas of amplitude (d cyl) and axis (d axis) between pre- and postoperatively and between postoperative periods.\(^{(52)}\)

**Control of astigmatism:**

It is possible prophylactically by recognizing and avoiding causative factors; intraoperative keratometry (Terry keratometer) is helpful in some cases.\(^{(53)}\) Certain methods can be used to correct preoperative and avoiding postoperative astigmatism:

1- **Incision construction and location:** A small, straight or frown, scleral tunnel incision is astigmatically more neutral than other incisions. The cornea flattens along the meridian of the tunnel incision, so it can be made in the steeper meridian. Clear corneal sutureless incision can be expected to drift 0.25 –0.5 D perpendicular to the incision.\(^{(11)}\)

2- **Astigmatic keratotomy:** Can be considered intraoperatively in patients with 1.5 –4.0 D preexisting astigmatism. Incisions are made in paracentral zone in the steeper meridian. Size, site and number
of cuts are predetermined according to degree and type of astigmatism. \(^{(11), (53)}\)

3- **Limbal relaxing incision (LRI):** Effective method for reducing 0.5 – 3.0 D. Advantages of LRI over AK are:

   a) Less postoperative glare.

   b) Preserving optical quality of the cornea.

   c) Minimizing discomfort.

   d) Quicker recovery of vision. \(^{(11), (54)}\)

4- Postoperatively the astigmatism may be corrected by removing sutures in the axis of the plus cylinder, if the cylinder is more than 3D.

5- Contact lens can be tried in irregular astigmatism.

6- PKP, if all the above measures are failed. \(^{(11)}\)

**The stability of the refraction:**

The refraction takes time to settle down. It is inversely related to the size of the incision. In classical large incision methods the refraction needs 6 weeks postoperative on average to settle down.

All these of course depend on the straight forward wound healing. Should this not occur because of inadequate closure technique or inadvertent inclusion of extraneous material (vitreous
or long capsule), the refraction may take a longer time to reach unchanging state and may end with a high astigmatism. Late changes in refraction may occur in the power and cylinder orientation due to fray of a tight suture, cystoid wound or shrinkage of the capsular bag. (39)
OBJECTIVES

1. To determine the prevalence of astigmatism following phacoemulsification technique compared with large incision ECCE with IOL in Makkah Eye Complex.

2. To find out the relation between the wound size and the degree of astigmatism following both techniques.

3. To compare the effect of suturing and number of sutures on the pattern of postoperative astigmatism in each group.

4. To explore other causes of postoperative astigmatism following both methods.
MATERIALS AND METHODS

2.1 Setting:

This study was conducted in Makkah Eye Complex, Khartoum, Sudan; it is one of the biggest ophthalmic centres in Sudan, in which most of the important ophthalmic operations are usually done. The study was carried out over a period of 12 months from 1/6/2004 - 31/5/2005.

Interviews and examinations were done in the outpatient department (OPD) and refraction department.

2.2 Study population:

Patients, who completed eight weeks following PCL implantation, were included in the study with a few exceptions.

2.2.1 Inclusion criteria:

a. All patients attended the 8th week follow-up and lived in Khartoum State or near by.

b. All patients lived in rural areas away from Khartoum State but they had no problem of transportation.
2.2.2 Exclusion criteria:

a. Patients developed postoperative complications like iris prolapse, endophthalmitis and shallow AC.

b. Patients who had had a vision threatening conditions like retinal detachment or advanced glaucoma.

c. Patients who had preoperative astigmatism or a difference of more than 1D between the vertical and horizontal meridians in keratometeric measurements.

d. Patients presented with conditions that interfere with accurate keratometry, such as corneal degeneration and pterygium.

2.2.3 Sample Size:

Two hundreds and sixty patients were included in the study, 130 had phaco and 130 had large incision ECCE with IOL implantation, 205 of them reach the final follow-up. Five patients were excluded from the phaco group due to pre-existing cause of very low vision; like ARMD, CRVO and diabetic maculopathy. So, the remaining patients were 200; half of them are of phaco group.
2.3 Procedures:

2.3.1 Study design:

This is a prospective comparative hospital based study.

2.3.2 Study Tools:

The following tools were used to examine patients at OPD and Refraction Department in Makkah Eye Complex

- Illuminated Snellen chart- E. type.
- Pen torch.
- Trial set.
- Trial frame.
- Streak retinoscope.
- Automated refractometer.
- Slit-Lamp biomicroscopy.
- Goldmann applanation tonometer.
- Keeler direct ophthalmoscope.
- Automated and ordinary calibrated keratometer (Haag-Streit).
- Binocular loupe.
• Antiseptic solutions.
• Toothed corneal forceps.
• A wire speculum.
• Eye drops (Tetracaine hydrochloride 0.5%, Tropicamide 1%).
• Cotton balls.
• Disposable syringes (1cc).

2.3.3 Methodology:

A questionnaire was designed and completed for each patient (appendix).

The questionnaire consisted of:

a. Clinical history: This includes personal data as well as the present and past ocular and medical history.

b. Aetiological type of cataract.

c. Visual acuity (VA) of the patients was checked with illuminated Snellen test type at a distance of six meters in a lightened room. VA of both eyes was recorded separately. In cases where the individuals were unable to recognize the largest test symbol, the fingers were used, and the distance reduced gradually till close to the
face. If fingers were not seen then hand was moved in front of the patient, if hand movements were not recognized then finally a small penlight be used to determine if the patient can perceive light and to test the projection of light. Visual acuity was done preoperatively and postoperatively.

d. Refraction was done for every patient; using manual or automated refractometer. Refraction was done preoperatively and postoperatively at 4\textsuperscript{th} weeks, 8\textsuperscript{th} weeks. It was also done at 12\textsuperscript{th} weeks; after removal of sutures in suspected patients.

e. Calculation of power of IOL: Corneal curvatures were recorded in two principal meridians with automated or a calibrated keratometer (Haag-Streit) based on the Javal Schiotz design, the mires are red and green objects and are internally illuminated. Axial length (AL) was measured with A-scan ultrasonography by applanation type of transducer attached with ultrasonic biometer of Teknar Company with assembly programmed with SRK II formula.
f. B-scan ultrasonography was done for every patient.

g. PCL was implanted to all patients.

h. Preoperative preparations: the pupils were dilated with Tropicamide 1% and every patients received two tablets of Acetazolamide (250 mg).

i. Operative techniques: Most operations were done under local anaesthesia (O'Brien facial akinesia with retrobulbar anaesthesia), while others under topical anaesthesia (few patients in phaco group). Incision with blade or knife was made. One of the two section sites were selected, limbal and post limbal. None of the study population had corneal incision.

I. Anterior chamber (AC) was entered with blade at about 11 o'clock position. In large incision ECCE, angled cystotome was used to perform can opening anterior capsulotomy after introduction of a viscoelastic solution. While in phaco group capsulorrhexis was performed.

II. AC was then opened 10-12mm from 10-2 o'clock with corneal scissors, in large incision
ECCE. In phaco, enlarged just to accommodate the phaco probe at first, then increased to 3-4mm or 5.5-6mm, according to type of IOL.

III. In LI ECCE, nucleus along with cortex was expressed out manually. Remaining cortex was washed out with a Simcoe's manual irrigating aspirating double way canula. Nuclear cracking and emulsification, or other technique, was the rule in phaco group. Ringer lactate or balance salt solutions were used as irrigation fluids.

IV. AC was reformed with the viscoelastic solution and PCL was implanted in the capsular bag. The lens was then rotated horizontally with a lens rotator, viscoelastic solution was washed out.

V. The section was closed with 10.0 monofilament nylon suture in all cases of LI ECCE with an average of 3 to 4 stitches. In phaco
group some patients were left without suturing, while in the others an average of 1 to 2 stitches were applied. A prophylactic 20 mg Gentamycin with 1 mg Dexamethazone were injected in upper or lower fornix at the end of the operation.

VI. Only Interrupted radial sutures with knots buried were used in appropriate patients. The sutures were placed approximately at the level of the Descemet’s membrane with initial reverse three throws and second single throw with horizontal pull.

VII. Postoperative topical steroid with antibiotics were used in almost all cases for 4-8 weeks with tapering system.

j. Follow-up: Each patient was followed for two months. Assessment of the cases were done at the first week, fourth and eighth week routinely in the hospital.

k. Patients attended the eighth week follow-up were our target in this study. Criteria for analysis were general
ophthalmic examination including both anterior and posterior segments, vision with pinhole, refraction and keratometric measurements.

I. Postoperative refractive errors were recorded either spherical or astigmatic. Astigmatism was recorded WTR or ATR. Sutures were removed in the same day using 1 cc disposable syringe, corneal forceps, local anaesthetic and a binocular loupe.

m. Patients; whose sutures were removed, were seen one month later i.e. at twelfth week; vision, refraction and keratometry were done in this visit.

n. Causes of postoperative astigmatism were explored.

2.4 Data analysis:

IBM compatible computer was utilized for data analysis using SPSS (Statistical Package for Social Sciences) programme. Chi-square test was used for categorized variables at 95% confidence level (P=0.05). Only P. value < 0.05 was considered to indicate significance. Computer programme (Excel) was used for graphical presentation.
2.5 Limitations of the study:

- Problem of follow up: a total number of 260 cases were included in this study, but only 205 patients attended the final follow-up. The rest of the patients could not complete the required duration of the follow-up.

- Shortage of calculating devices: there is only two keratometers for preoperative IOL calculation and postoperative keratometry. This made postoperative keratometry so difficult.

- Lack of more sophisticated instrument like photokeratoscope to measure postoperative astigmatism, and corneal topography is very expensive. In our study, we used only keratometer.
RESULTS

A total of 260 cases were included in the study, but only 205 patients attended the final follow up. One hundred and five patients of the phaco group and 100 patients of the large incision group. Five patients of the former group were excluded.

3.1. Demographic data:

Fifty-nine patients (59%) of the phaco group were males and 41 (41%) were females. In the large incision group 58 patients (58%) were males and 42 (42%) were females (Figure 1, 2). The ages ranged between 26 and 78 years in the former and between 31 and 75 years in the later with an obvious predilection for those above 60 years.

The operated eye was R eye in 58%, and L eye in 42% in the former, while it was 62% and 38% respectively in the later (Figure 3, 4).

3.2. Aetiology of cataract:

All patients of phaco group had a senile cataract, while 99 patients (99%) had a senile cataract and only one (1%) was due to trauma, in the large incision group.
3.3. Preoperative VA:

Percentage of patients had a vision of less than 6/60 were (46%), (37%) ranged from 6/24 to 6/60 and the others (17%) were 6/18 or better in phaco group. Most of patients had a vision of less than 6/60 (84%), (13%) ranged from 6/24 to 6/60 and the others (3%) were 6/18 or better in large incision group (Table 1) (Figure 5,6,7).

3.4. Keratometry:

The mean dioptric power of the corneae vertically was 42.85 ± 1.31D and horizontally was 42.96 ± 1.16D in phaco group, while they were 43.71 ± 1.76D vertically and 43.74 ± 1.66D horizontally in large incision group preoperatively. Postoperatively, vertically was 42.84 ± 1.33D and horizontally was 42.91 ± 1.16D in phaco group, while they were 43.56 ± 1.86D vertically and 43.62 ± 1.83D horizontally in large incision group preoperatively. The correlation between the mean of differences (vertical – vertical) and (horizontal – horizontal) powers (pre - postoperatively) was highly significant (P value 0.00) in each group separately.
3.5. Power of IOL:

PCL was implanted in all patients, the power ranged from 4.0 to 29.0D, mean was 20.98 ± 0.33D in phaco patients, while it was from 11.5 to 26.0D in large incision patients, with a mean 20.32 ± 0.23D. Thirty-four percent of phaco group had foldable IOL, while (66%) had small diameter (5.5mm) one. Only (1%) of the large incision group had small diameter IOL, and the remaining (99%) had standard PMMA IOL (Figure 8,9).

3.6. Type of anaesthesia:

All patients in each group had received local anaesthesia, except one patient in phaco group, who had topical anaesthesia.

3.7. Type of incision:

Incision was limbal in all patients (100%) in phaco group and (99%) in large incision group, the post-limbal incision (1%) is not a routine in this hospital.

3.8. Wound size:

Thirty-four percent of phaco group had 3.0-5.0mm incision, and 66% had >5.0-7.0mm incision, compared with 1% had >5.0-7.0mm and 99% had >7.0mm in large incision group (Table 2) (Figure 10,11).
3.9. Mode of suturing:

All sutured incisions; (22%) in phaco and (100%) in large incision groups, were closed with 10/0 monofilament nylon with interrupted radial sutures. Seventy-eight percent was sutureless in phaco group (Figure 12).

3.10. Number of stitches:

Nineteen percent had 1-2 stitches and (3%) had 3-4 stitches in phaco group, while in large incision group, (3%) had 1-2 stitches, (94%) had 3-4 stitches and the other (3%) had more than 4 stitches (Table 3) (Figure 13,14).

3.11. Wound closure (3-7 days after surgery):

All wounds were sealed in each group, no incidence of wound gap, iris prolapse or vitreous incarceration.

3.12. Status of suturing (3-7 days after surgery):

Only two patients in the phaco group had visible tight sutures, none had loose or broken suture. Although statistically not Significant; when related to SIA measured by keratometer in the large incision group, there were 20 patients (20%) had visibly tight sutures, one (1%) loose and 1 (1%) broken sutures; P. value 0.73 (Table 4, 5).
3.13. Pupil shape (3-7 days after surgery):

All pupils in phaco group had regular contour, except one (1%) was distorted. There were 3 (3%) distorted in large incision group. This was not related to malposition of IOL or vitreous prolapse in the AC. When related to keratometric changes, they were not significant; P. values were 0.67 and 0.94 respectively.

3.14. Malposition of IOL (3-7 days after surgery):

Only one patient in each group had a slightly decentered IOL.

3.15. Status of the posterior capsule (3-7 days after surgery):

Posterior capsule was intact in all patients.

3.16. Postoperative best corrected vision (BCV) at the 8th week:

Ninety-seven patients (97%) of phaco group had vision of 6/18 or better at 8th week, the ratio was (79%) in large incision group. The comparison between the two groups was highly significant (P. value 0.00). When the BCV of those whose sutures were removed compared with phaco group, there was no difference (P. value 0.35) (Table 6,7).

3.17. Degree of POA (by Refraction):

The amount of astigmatism measured by refraction was not normally distributed (skewed), so we used the median± 25th or 75th
centile, instead of the mean± std. deviation. The degree of postoperative astigmatism was stable after the 4th week in phaco group, while still changing up to the 12th week; after removal of suture, in large incision group (Table 8,9). Postoperative astigmatism (POA); 1.00 D (range 0.50 to 1.50D) in phaco patients, was less than that caused by large incision; 3.25 (range 1.50 to 5.50D). The comparison was highly significant at the 8th week (P. value 0.00), but less significant after removal of sutures (P. value 0.029) (Table 10,11). When phaco; with foldable IOL, compared with phaco; with small diameter IOL, there were no differences (P. value 0.26) (Table 12).

3.18. Type of postoperative astigmatism (P.O.A.) (by Refraction):

In the phaco group, twenty-eight patients (28%) had WTR astigmatism at the 4th week, the number reduced to 23 patients (23%) at the 8th week, 63 patients (63%) developed ATR at the 4th week, the ratio increased to 67 patients (67%) at the 8th week, 8 patients (8%) had no astigmatism at the 4th week, the ratio increased to 10 patients (10%) at the 8th week and the number of patients with unclear refraction decreased from one to zero. These
relations were not significant (P value 0.61). In large incision group, WTR astigmatism reduced from 48 patients (48%) to 41 patients (41%), ATR increased from 39 patients (39%) to 52 patients (52%), neutral refraction reduced from 9 to 4 patients and unclear refraction decreased from 4 to 2 patients. These relations were significant (P. value 0.01) (Figure 15,16). The comparison between the two groups showed that phaco induced ATR astigmatism more than LI ECCE, and vice versa regarding WTR astigmatism (P. values were 0.01 at the 4th week, and 0.009 at the 8th week) (Figure 17,18)

3.19. Degree of postoperative astigmatism (by Keratometer):

To calculate the surgical induced astigmatism, using subtraction method, the differences between vertical and horizontal powers of the cornea; preoperatively then postoperatively, were calculated. The preoperative differences were subtracted from the postoperative ones. The changes were highly significant in large incision group (P. value 0.00), but not in phaco group (P. 0.089) (table 13,14). The large incision cataract surgery induced more postoperative astigmatism than small incision (P. value 0.00) (table 15). There were no differences, when phaco; with foldable IOL,
compared with phaco; with small diameter IOL (P. value 0.49) (table 16).

3.19.1. Degree of surgical induced astigmatism (by Keratometer) in relation to the wound size:

The relation between the degree of surgical induced astigmatism and the wound size was not significant in each group separately; P. values were 0.49 in phaco and 0.92 in large incision (table 17,18). When both were compared; regarding the wound size, large incision (>7mm) induced more postoperative astigmatism (P. value 0.00) (table 19).

3.19.2 Degree of surgical induced astigmatism (by Keratometer) in relation to the number of stitches:

Although, it was highly significant after pooling of the two groups (P. value 0.00), There was no relation observed between the degree of surgical induced astigmatism and the number of stitches in each group separately; P. value 0.99 in phaco and 0.75 in large incision (table 20,21,22).
3.19.3. Degree of surgical induced astigmatism (by Keratometer) in relation to mode of suturing:

The mode of suturing was studied after pooling of the two groups, interrupted sutures induced significant amount of astigmatism more than sutureless wounds (P.value 0.00) (Tables 23).

3.19.4. Degree of surgical induced astigmatism (by Keratometer) in relation to the operated eye:

It was noted that the right eyes had more postoperative astigmatism (0.79 ± 1.26D) than the left eyes (0.51± 0.44) in phaco group, and the right eyes had (1.65 ± 1.9D) compared with (1.48 ± 1.05) in the left eyes of large incision; P. values were 0.16 in phaco and 0.6 in large incision. After pooling all groups, the relation was not significant (P. value 0.2) (Tables 24,25).
3.20. Type of surgical induced astigmatism (by Keratometer) in relation to the type of surgery:

ATR astigmatism was found to be more in phaco group (50%) than large incision group (47%), and vice versa in WTR astigmatism; (35%) compared with (46%), respectively. The relation was not significant; (P. value 0.1) (Table 26).

3.20.1. Type of surgical induced astigmatism (by Keratometer) in relation to the wound size:

Type postoperative astigmatism was studied in relation to wound size (table 27,28). The study was not significant within each group separately; P. value 0.43 for phaco, 0.56 for large incision at 8th week and 0.36 after removal of suture (Table 29).

3.20.2. Type of surgical induced astigmatism (by Keratometer) in relation to the number of stitches:

No differences was observed between sutureless, 1-2 and 3-4 stitches in relation to the type of postoperative astigmatism; in phaco (P. value 0.36), also (P. value was 0.87 0.19) in large incision before and after removal of suture, respectively (Table 30,31,32).
3.20.3. Type of surgical induced astigmatism (by Keratometer) in relation to the period of steroid usage:

The correlation between use of steroid and development of postoperative astigmatism; type (WTR or ATR) or degree, was negative for each group. P. value (0.21 and 0.79) for phaco, (0.85 and 0.41) for large incision group (Table 33,34,35,36,37).

3.21. Postoperative complications:

3.21.1 Suture reaction: Most eye were quiet 2month postoperatively, except 3% of phaco group and 16% of large incision group (Table 38).

3.21.2 Malposition of IOL: Only 2% of each group had decentered IOL at the 8th postoperative (Table 39).

3.21.3 Opacity of the posterior capsule: The incidence of PCO was 8% of phaco group and 10% of the large group (Table 40).

3.21.4 Other complications: Corneal oedema, FB sensation and mild uveitis, also reported in few cases (Table 40).
Table 1: Preoperative visual acuity in phaco and large incision groups:

(n = 100 in phaco, n = 100 in large incision)

<table>
<thead>
<tr>
<th>V.A.</th>
<th>Phaco No. of patients</th>
<th>Large incision No. of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>6/6</td>
<td>01</td>
<td>00</td>
</tr>
<tr>
<td>6/9</td>
<td>01</td>
<td>00</td>
</tr>
<tr>
<td>6/12</td>
<td>04</td>
<td>00</td>
</tr>
<tr>
<td>6/18</td>
<td>11</td>
<td>03</td>
</tr>
<tr>
<td>6/24</td>
<td>10</td>
<td>01</td>
</tr>
<tr>
<td>6/36</td>
<td>08</td>
<td>05</td>
</tr>
<tr>
<td>6/60</td>
<td>19</td>
<td>07</td>
</tr>
<tr>
<td>&lt;6/60</td>
<td>46</td>
<td>84</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>
Table 2: The wound size in phaco and large incision patients:

(n = 100 in phaco, n = 100 in large incision)

<table>
<thead>
<tr>
<th>Wound size in mm</th>
<th>Phaco</th>
<th>Large incision</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of patients</td>
<td>%</td>
</tr>
<tr>
<td>3- 5</td>
<td>34</td>
<td>34</td>
</tr>
<tr>
<td>&gt;5- 7</td>
<td>66</td>
<td>66</td>
</tr>
<tr>
<td>&gt;7</td>
<td>00</td>
<td>00</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>
Table 3: The number of stitches in phaco and large incision patients:

(n = 100 in phaco, n = 100 in large incision)

<table>
<thead>
<tr>
<th>Number of stitches</th>
<th>Phaco</th>
<th></th>
<th>Large incision</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of patients</td>
<td>%</td>
<td>No. of patients</td>
<td>%</td>
</tr>
<tr>
<td>No stitch</td>
<td>78</td>
<td>78</td>
<td>00</td>
<td>00</td>
</tr>
<tr>
<td>1-2</td>
<td>19</td>
<td>19</td>
<td>03</td>
<td>03</td>
</tr>
<tr>
<td>3-4</td>
<td>03</td>
<td>03</td>
<td>94</td>
<td>94</td>
</tr>
<tr>
<td>&gt; 4</td>
<td>00</td>
<td>00</td>
<td>03</td>
<td>03</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>
Table 4: The status of sutures 3-7 days after surgery:
(n = 100 in phaco, n = 100 in large incision)

<table>
<thead>
<tr>
<th>Status of sutures</th>
<th>Phaco</th>
<th></th>
<th>Large incision</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of patients</td>
<td>%</td>
<td>No. of patients</td>
<td>%</td>
</tr>
<tr>
<td>tight</td>
<td>02</td>
<td>02</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>loose</td>
<td>00</td>
<td>00</td>
<td>01</td>
<td>01</td>
</tr>
<tr>
<td>broken</td>
<td>00</td>
<td>00</td>
<td>01</td>
<td>01</td>
</tr>
<tr>
<td>normal</td>
<td>98</td>
<td>98</td>
<td>78</td>
<td>78</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>
Table 5: The degree of postoperative astigmatism (by keratometer) in relation to status of sutures in large incision group:

(n= 100)

<table>
<thead>
<tr>
<th>Status of sutures</th>
<th>No. of patients</th>
<th>Mean of astigmatism in D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tight</td>
<td>20</td>
<td>1.33</td>
</tr>
<tr>
<td>Loose</td>
<td>01</td>
<td>0.5</td>
</tr>
<tr>
<td>Broken</td>
<td>01</td>
<td>1.25</td>
</tr>
<tr>
<td>Normal</td>
<td>78</td>
<td>1.61</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

P. value 0.73
Table 6: Postoperative BCV, comparison between phaco and large incision patients in the 8th week:

(n= 100 in phaco and n= 100 in Large incision)

<table>
<thead>
<tr>
<th>BCV</th>
<th>Phaco %</th>
<th>Large incision %</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;6/18</td>
<td>97</td>
<td>79</td>
</tr>
<tr>
<td>6/24-6/60</td>
<td>03</td>
<td>16</td>
</tr>
<tr>
<td>&lt;6/60</td>
<td>00</td>
<td>05</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

P. value 0.00
Table 7: Postoperative BCV, comparison between phaco and large incision patients after removal of sutures:

(n= 100 in phaco and n= 29 in Large incision)

<table>
<thead>
<tr>
<th>BCV</th>
<th>Phaco %</th>
<th>Large incision %</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;6/18</td>
<td>97</td>
<td>100</td>
</tr>
<tr>
<td>6/24-6/60</td>
<td>03</td>
<td>00</td>
</tr>
<tr>
<td>&lt;6/60</td>
<td>00</td>
<td>00</td>
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<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

P. value 0.35
Table 8: Changes in the degree of postoperative astigmatism (by refraction) in relation to the time in phaco:

(n = 100)

<table>
<thead>
<tr>
<th>Time</th>
<th>Median</th>
<th>25&lt;sup&gt;th&lt;/sup&gt;</th>
<th>75&lt;sup&gt;th&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>4&lt;sup&gt;th&lt;/sup&gt; week</td>
<td>1.00</td>
<td>0.50</td>
<td>1.50</td>
</tr>
<tr>
<td>8&lt;sup&gt;th&lt;/sup&gt; week</td>
<td>1.00</td>
<td>0.50</td>
<td>1.50</td>
</tr>
</tbody>
</table>

P. value 0.89

Table 9: Changes in the degree of postoperative astigmatism (POA) (by refraction) in relation to the time in large incision:

(n = 100 in large incision)

<table>
<thead>
<tr>
<th>Time</th>
<th>√mean</th>
<th>√standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>4&lt;sup&gt;th&lt;/sup&gt; week</td>
<td>1.71</td>
<td>0.89</td>
</tr>
<tr>
<td>8&lt;sup&gt;th&lt;/sup&gt; week</td>
<td>1.64</td>
<td>0.82</td>
</tr>
<tr>
<td>12&lt;sup&gt;th&lt;/sup&gt; week</td>
<td>1.19</td>
<td>0.36</td>
</tr>
</tbody>
</table>

P. value 0.01
Table 10: Comparison between phaco and large incision in relation to the degree of P.O.A. in dioptres at the 8th postoperative week:

<table>
<thead>
<tr>
<th>Type of surgery</th>
<th>Refraction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Median</td>
</tr>
<tr>
<td>Phaco</td>
<td>1.00</td>
</tr>
<tr>
<td>Large incision</td>
<td>3.25</td>
</tr>
</tbody>
</table>

P. value 0.00
Table 11: Comparison between phaco and large incision after removal of suture (by refraction) at $8^{th}$ week regarding the degree of POA:

(n= 129)

<table>
<thead>
<tr>
<th>Type of surgery</th>
<th>No. of patients</th>
<th>Refraction $\sqrt{\text{mean}}$</th>
<th>$\sqrt{\text{std. deviation}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phaco</td>
<td>100</td>
<td>0.98</td>
<td>0.47</td>
</tr>
<tr>
<td>Large incision</td>
<td>29</td>
<td>1.19</td>
<td>0.07</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>129</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

P. value 0.029

Table 12: Comparison between phaco with foldable IOL and phaco with small diameter IOL at $8^{th}$ week regarding the degree of POA (by refraction):

(n= 100)

<table>
<thead>
<tr>
<th>Type of IOL</th>
<th>No. of patients</th>
<th>$\sqrt{\text{mean}}$</th>
<th>$\sqrt{\text{Std. Deviation}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foldable</td>
<td>34</td>
<td>0.91</td>
<td>0.45</td>
</tr>
<tr>
<td>Small diameter</td>
<td>66</td>
<td>1.02</td>
<td>0.48</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

P. value 0.26
Table 13: The degree of postoperative astigmatism (by Keratometer) at the 8th week compared with preoperative one in phaco group:

\[(n = 100)\]

<table>
<thead>
<tr>
<th>Astigmatism</th>
<th>No. of patients</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>preoperative</td>
<td>100</td>
<td>0.51</td>
<td>0.34</td>
</tr>
<tr>
<td>postoperative</td>
<td>100</td>
<td>0.68</td>
<td>1.01</td>
</tr>
</tbody>
</table>

P. value 0.89

Table 14: The degree of postoperative astigmatism (by Keratometer) at the 8th week compared with preoperative one in Large incision group:

\[(n = 100)\]

<table>
<thead>
<tr>
<th>Astigmatism</th>
<th>No. of patients</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>preoperative</td>
<td>100</td>
<td>0.64</td>
<td>0.72</td>
</tr>
<tr>
<td>postoperative</td>
<td>100</td>
<td>1.59</td>
<td>1.62</td>
</tr>
</tbody>
</table>

P. value 0.00
Table 15: The degree of postoperative astigmatism (by Keratometer) at the 8th week, comparison between phaco and Large incision group:

(n = 100)

<table>
<thead>
<tr>
<th>Astigmatism</th>
<th>No. of patients</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phaco</td>
<td>100</td>
<td>0.68</td>
<td>1.02</td>
</tr>
<tr>
<td>Large incision</td>
<td>100</td>
<td>1.59</td>
<td>1.62</td>
</tr>
<tr>
<td>Total</td>
<td>200</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

P. value 0.00

Table 16: The degree of POA (by Keratometer) at the 8th week, comparison phaco foldable and small diameter IOLs:

(n = 100)

<table>
<thead>
<tr>
<th>Type of IOL</th>
<th>No. of patients</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foldable</td>
<td>34</td>
<td>0.58</td>
<td>0.42</td>
</tr>
<tr>
<td>Small diameter</td>
<td>66</td>
<td>0.73</td>
<td>1.20</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

P. value 0.49
Table 17: The degree of POA (by Keratometer) in relation to the wound size in phaco group:

\[(n = 100)\]

<table>
<thead>
<tr>
<th>Wound size in mm</th>
<th>No. of patients</th>
<th>Keratometer mean</th>
<th>standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-5</td>
<td>34</td>
<td>0.58</td>
<td>0.42</td>
</tr>
<tr>
<td>5-7</td>
<td>66</td>
<td>0.73</td>
<td>1.20</td>
</tr>
<tr>
<td>&gt; 7</td>
<td>00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

P. value 0.49
Table 18: The degree of POA (by Keratometer) in relation to the wound size in large incision group:

\[(n = 100)\]

<table>
<thead>
<tr>
<th>Wound size in mm</th>
<th>No. of patients</th>
<th>Keratometer mean</th>
<th>Keratometer standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-5</td>
<td>00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>5-7</td>
<td>01</td>
<td>1.75</td>
<td>0.00</td>
</tr>
<tr>
<td>&gt; 7</td>
<td>99</td>
<td>1.58</td>
<td>1.63</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

P. value 0.92
Table 19: The degree of POA (by Keratometer) in relation to the wound size in study sample:
(n = 200)

<table>
<thead>
<tr>
<th>Wound size in mm</th>
<th>No. of patients</th>
<th>Keratometer mean</th>
<th>standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-5</td>
<td>34</td>
<td>0.58</td>
<td>0.42</td>
</tr>
<tr>
<td>5-7</td>
<td>67</td>
<td>0.74</td>
<td>1.20</td>
</tr>
<tr>
<td>&gt; 7</td>
<td>99</td>
<td>1.58</td>
<td>1.63</td>
</tr>
<tr>
<td>Total</td>
<td>200</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

P. value 0.00
Table 20: The degree of POA (by Keratometer) in relation to the number of stitches in phaco group:

*(n = 100)*

<table>
<thead>
<tr>
<th>Number of stitches</th>
<th>No. of patients</th>
<th>Keratometer mean</th>
<th>standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>No stitch</td>
<td>78</td>
<td>0.67</td>
<td>1.101</td>
</tr>
<tr>
<td>1-2</td>
<td>19</td>
<td>0.70</td>
<td>0.48</td>
</tr>
<tr>
<td>3-4</td>
<td>03</td>
<td>0.67</td>
<td>0.76</td>
</tr>
<tr>
<td>&gt; 4</td>
<td>00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

P. value 0.99
Table 21: The degree of POA (by Keratometer) in relation to the number of stitches in large incision group:
(n = 100)

<table>
<thead>
<tr>
<th>Number of stitches</th>
<th>No. of patients</th>
<th>Keratometer mean</th>
<th>standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>No stitch</td>
<td>00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>1-2</td>
<td>03</td>
<td>1.83</td>
<td>0.14</td>
</tr>
<tr>
<td>3-4</td>
<td>93</td>
<td>1.60</td>
<td>1.67</td>
</tr>
<tr>
<td>&gt; 4</td>
<td>03</td>
<td>0.92</td>
<td>0.72</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

P. value 0.75
Table 22: The degree of POA (by Keratometer) in relation to the number of stitches in study sample:

(n = 200)

<table>
<thead>
<tr>
<th>Number of stitches</th>
<th>No. of patients</th>
<th>Keratometer mean</th>
<th>Keratometer standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>No stitch</td>
<td>78</td>
<td>0.67</td>
<td>1.11</td>
</tr>
<tr>
<td>1-2</td>
<td>22</td>
<td>0.85</td>
<td>0.60</td>
</tr>
<tr>
<td>3-4</td>
<td>97</td>
<td>1.57</td>
<td>1.65</td>
</tr>
<tr>
<td>&gt; 4</td>
<td>03</td>
<td>0.92</td>
<td>0.72</td>
</tr>
<tr>
<td>Total</td>
<td>200</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

P. value 0.00
Table 23: The degree of postoperative astigmatism (by Keratometer) in relation to the mode of suturing in the study sample: (n = 200)

<table>
<thead>
<tr>
<th>Mode of suturing</th>
<th>No. of patients</th>
<th>Mean</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sutureless</td>
<td>78</td>
<td>0.67</td>
<td>1.11</td>
</tr>
<tr>
<td>Interrupted</td>
<td>122</td>
<td>1.42</td>
<td>1.52</td>
</tr>
<tr>
<td>Total</td>
<td>200</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

P. value 0.00

Table 24: The degree of postoperative astigmatism in relation to the operated eye in phaco: (n = 100)

<table>
<thead>
<tr>
<th>Operated eye</th>
<th>No. of patients</th>
<th>Mean of astigmatism</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>58</td>
<td>0.80</td>
</tr>
<tr>
<td>L</td>
<td>42</td>
<td>0.51</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

P. value 0.16
Table 25: The degree of postoperative astigmatism in relation to the operated eye in large incision:

(n = 100)

<table>
<thead>
<tr>
<th>Operated eye</th>
<th>No. of patient</th>
<th>Mean of astigmatism</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>62</td>
<td>1.65</td>
</tr>
<tr>
<td>L</td>
<td>38</td>
<td>1.48</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

P. value 0.3
Table 26: The type of postoperative astigmatism (by Keratometer) in relation to the type of surgery:

(n = 100 in phaco, n = 100 in large incision)

<table>
<thead>
<tr>
<th>Type of astigmatism</th>
<th>Phaco</th>
<th>Large incision</th>
<th>P. value 0.10</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>Mean D</td>
<td>%</td>
</tr>
<tr>
<td>neutral</td>
<td>15</td>
<td>00.00</td>
<td>07</td>
</tr>
<tr>
<td>WTR</td>
<td>35</td>
<td>00.86</td>
<td>47</td>
</tr>
<tr>
<td>ATR</td>
<td>50</td>
<td>00.75</td>
<td>46</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>
Table 27: The type of POA (by Keratometer) in relation to the wound size in phaco:

(n = 100)

<table>
<thead>
<tr>
<th>Wound size in mm</th>
<th>Neutral %</th>
<th>WTR %</th>
<th>ATR %</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-5</td>
<td>03</td>
<td>12</td>
<td>19</td>
<td>34</td>
</tr>
<tr>
<td>&gt;5-7</td>
<td>12</td>
<td>23</td>
<td>31</td>
<td>66</td>
</tr>
<tr>
<td>&gt; 7</td>
<td>00</td>
<td>00</td>
<td>00</td>
<td>00</td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
<td>35</td>
<td>50</td>
<td>100</td>
</tr>
</tbody>
</table>

P. value 0.43
Table 28: The type of POA (by Keratometer) at the 8th week in relation to the wound size in large incision:

(n = 100)

<table>
<thead>
<tr>
<th>Wound size in mm</th>
<th>Neutral</th>
<th>WTR</th>
<th>ATR</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-5</td>
<td>00</td>
<td>00</td>
<td>00</td>
</tr>
<tr>
<td>&gt;5-7</td>
<td>00</td>
<td>00</td>
<td>01</td>
</tr>
<tr>
<td>&gt; 7</td>
<td>07</td>
<td>47</td>
<td>45</td>
</tr>
<tr>
<td>Total</td>
<td>07</td>
<td>47</td>
<td>46</td>
</tr>
</tbody>
</table>

P. value 0.56
Table 29: The type of postoperative astigmatism (by Keratometer) after removal of sutures in relation to the wound size in large incision:

\[(n = 29)\]

<table>
<thead>
<tr>
<th>Wound size in mm</th>
<th>Neutral</th>
<th>WTR</th>
<th>ATR</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td>%</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>3-5</td>
<td>00.00</td>
<td>00.00</td>
<td>00.00</td>
</tr>
<tr>
<td>&gt;5-7</td>
<td>00.00</td>
<td>00.00</td>
<td>03.44</td>
</tr>
<tr>
<td>&gt; 7</td>
<td>00.00</td>
<td>44.82</td>
<td>51.74</td>
</tr>
<tr>
<td>Total</td>
<td>00.00</td>
<td>44.82</td>
<td>55.18</td>
</tr>
</tbody>
</table>

P. value 0.36
Table 30: The type of postoperative astigmatism (by Keratometer) in relation to the number of stitches in phaco:

(n = 100)

<table>
<thead>
<tr>
<th>Number of stitches</th>
<th>Neutral %</th>
<th>WTR %</th>
<th>ATR %</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No stitch</td>
<td>11</td>
<td>31</td>
<td>36</td>
<td>78</td>
</tr>
<tr>
<td>1-2</td>
<td>03</td>
<td>04</td>
<td>12</td>
<td>19</td>
</tr>
<tr>
<td>3-4</td>
<td>01</td>
<td>00</td>
<td>02</td>
<td>03</td>
</tr>
<tr>
<td>&gt; 4</td>
<td>00</td>
<td>00</td>
<td>00</td>
<td>00</td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
<td>35</td>
<td>50</td>
<td>100</td>
</tr>
</tbody>
</table>

P. value 0.36
Table 31: The type of postoperative astigmatism (by Keratometer) in relation to the number of stitches in large incision:

(n = 100)

<table>
<thead>
<tr>
<th>Number of stitches</th>
<th>Neutral %</th>
<th>WTR %</th>
<th>ATR %</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No stitch</td>
<td>00</td>
<td>00</td>
<td>00</td>
<td>00</td>
</tr>
<tr>
<td>1-2</td>
<td>00</td>
<td>02</td>
<td>01</td>
<td>03</td>
</tr>
<tr>
<td>3-4</td>
<td>07</td>
<td>43</td>
<td>44</td>
<td>84</td>
</tr>
<tr>
<td>&gt; 4</td>
<td>00</td>
<td>02</td>
<td>01</td>
<td>03</td>
</tr>
<tr>
<td>Total</td>
<td>07</td>
<td>47</td>
<td>46</td>
<td>100</td>
</tr>
</tbody>
</table>

P. value 0.87
Table 32: The type of postoperative astigmatism (by Keratometer) in relation to the number of stitches in large incision after removal of sutures:

(n = 29)

<table>
<thead>
<tr>
<th>Number of stitches</th>
<th>Neutral %</th>
<th>WTR %</th>
<th>ATR %</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No stitch</td>
<td>00.00</td>
<td>00.00</td>
<td>00.00</td>
<td>00.00</td>
</tr>
<tr>
<td>1-2</td>
<td>00.00</td>
<td>00.00</td>
<td>06.90</td>
<td>06.90</td>
</tr>
<tr>
<td>3-4</td>
<td>00.00</td>
<td>44.82</td>
<td>48.28</td>
<td>93.10</td>
</tr>
<tr>
<td>&gt; 4</td>
<td>00.00</td>
<td>00.00</td>
<td>00.00</td>
<td>00.00</td>
</tr>
<tr>
<td>Total</td>
<td>00.00</td>
<td>44.82</td>
<td>55.18</td>
<td>100</td>
</tr>
</tbody>
</table>

P. value 0.19
Table 33: Period of steroid use in phaco and large incision patients:
(n= 100 in phaco and n= 100 in Large incision)

<table>
<thead>
<tr>
<th>Period</th>
<th>Phaco %</th>
<th>Large incision %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 month</td>
<td>97</td>
<td>96</td>
</tr>
<tr>
<td>2 months</td>
<td>00</td>
<td>04</td>
</tr>
<tr>
<td>3 moths</td>
<td>03</td>
<td>00</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 34: type of postoperative astigmatism (by keratometer) in relation to the period of steroid use in phaco:
(n= 100)

<table>
<thead>
<tr>
<th>Period</th>
<th>Neutral %</th>
<th>WTR %</th>
<th>ATR %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 month</td>
<td>15</td>
<td>35</td>
<td>47</td>
</tr>
<tr>
<td>2 months</td>
<td>00</td>
<td>00</td>
<td>00</td>
</tr>
<tr>
<td>3 moths</td>
<td>00</td>
<td>00</td>
<td>03</td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
<td>35</td>
<td>50</td>
</tr>
</tbody>
</table>

P. value 0.79
Table 35: Type of postoperative astigmatism (by keratometer) in relation to the period of steroid use in large incision:

(n= 100)

<table>
<thead>
<tr>
<th>Period</th>
<th>Neutral %</th>
<th>WTR %</th>
<th>ATR %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 month</td>
<td>07</td>
<td>44</td>
<td>47</td>
</tr>
<tr>
<td>2 months</td>
<td>00</td>
<td>03</td>
<td>02</td>
</tr>
<tr>
<td>3 months</td>
<td>00</td>
<td>00</td>
<td>03</td>
</tr>
<tr>
<td>Total</td>
<td>07</td>
<td>47</td>
<td>46</td>
</tr>
</tbody>
</table>

P. value 0.41
Table 36: The degree of postoperative astigmatism (by Keratometer) in relation to the period of steroid use in phaco:

(n = 100)

<table>
<thead>
<tr>
<th>Period of use</th>
<th>No. of patients</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 month</td>
<td>97</td>
<td>0.67</td>
<td>1.02</td>
</tr>
<tr>
<td>2 month</td>
<td>00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>3 month</td>
<td>03</td>
<td>0.83</td>
<td>0.58</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

P. value 0.79
Table 37: The degree of POA (by Keratometer) in relation to the period of steroid use in Large incision:

(n = 100)

<table>
<thead>
<tr>
<th>Period of use</th>
<th>No. of patients</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 month</td>
<td>96</td>
<td>1.56</td>
<td>1.64</td>
</tr>
<tr>
<td>2 month</td>
<td>04</td>
<td>2.25</td>
<td>0.34</td>
</tr>
<tr>
<td>3 month</td>
<td>00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

P. value 0.41

Table 38: Frequency of suture reaction in each group:

(n=100 n phaco and  n=100 in large incision)

<table>
<thead>
<tr>
<th>Tissue response</th>
<th>Phaco %</th>
<th>Large incision %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suture reaction</td>
<td>03</td>
<td>16</td>
</tr>
<tr>
<td>Quiet eye</td>
<td>97</td>
<td>84</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>
Table 39: Frequency of malposition of IOL in each group:

(n=100 n phaco and n=100 in large incision)

<table>
<thead>
<tr>
<th>Position of IOL</th>
<th>Phaco %</th>
<th>Large incision %</th>
</tr>
</thead>
<tbody>
<tr>
<td>In place</td>
<td>98</td>
<td>98</td>
</tr>
<tr>
<td>Decentered</td>
<td>02</td>
<td>02</td>
</tr>
<tr>
<td>Dislocated</td>
<td>00</td>
<td>00</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 40: Frequency of postoperative complications in each group:

(n=100 n phaco and n=100 in large incision)

<table>
<thead>
<tr>
<th>Complication</th>
<th>Phaco %</th>
<th>Large incision %</th>
</tr>
</thead>
<tbody>
<tr>
<td>No complication</td>
<td>86</td>
<td>79</td>
</tr>
<tr>
<td>PCO</td>
<td>08</td>
<td>10</td>
</tr>
<tr>
<td>Corneal oedema</td>
<td>02</td>
<td>02</td>
</tr>
<tr>
<td>Suture problems</td>
<td>00</td>
<td>03</td>
</tr>
<tr>
<td>Others</td>
<td>04</td>
<td>06</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>
DISCUSSION

Two hundred and sixty patients were included in this study, 55 of them were failed to reach the final follow-up, and this may be due to the following:

1- Feeling of improvement.
2- Financial problems.
3- Phobia from deterioration should any further intervention attempted.
4- Difficulty in transportation especially in autumn.

The result showed predominance of males, who constituted 58% in large incision and 59% in phaco group, this could be explained by the ability of men; financially and physically, to seek for medical advise.

The age of patients in the study group was distributed between 26 and 78 years with obvious predilection for those above 60 years. Almost all patients (100% in phaco and 99% in LI ECCE) had senile cataract.

Most of LI ECCE patients (84%) had preoperative VA of less than 6/60, while in phaco only (46%) had similar VA; this reflected
the early presentation of phaco patients when seeking visual improvement (Figure 7).

Visual improvement was by far the most common indication for cataract surgery, although requirement varied from person to person. At the 8th postoperative week, patients who were undergone phaco surgery gained better BCV than LI ECCE. Ninety seven percent of phaco group had VA 6/18 or better, compared with 79% of LI ECCE (Table 6). Same results obtained by Minassiana D C et al, but the percentages were less; 69% versus 57%, because the landmark was 6/9 or better. (55) Yi D H and Sullivan BR; in Dallas, USA, found that phacoemulsification had led to better postoperative visual acuity than manual expression ECCE even in advanced cataract. (56) Same results were obtained by Liu Y and Li S in China. (57) A Chinese surgeon stated that phaco is a safer and reliable surgery for restoration of visual acuity in patients with cataract, and it is superior to ECCE. (58) Heslin KB and Guerriero PN, agreed that patients in the phaco group experienced significantly better vision overall. (59) Claoue C and Hicks C found that, patients who had small and scleral incisions had better uncorrected visual acuities 6 weeks postoperatively because they had less astigmatism. (60)
Postoperative astigmatism (POA):

Postoperative astigmatism was detected by two methods, first; by refraction at the 4th, the 8th week and after one month of removal of sutures in patients whose sutures were removed. Preoperative refraction was not helpful, because most of the study population (65%) had faint or no fundal reflex. So, SIA cannot be calculated. The second method was keratometry, which was conducted preoperatively and in the last follow up postoperatively. SIA was calculated by subtracting the preoperative from postoperative astigmatism by simple subtraction method. Astigmatism was defined by degree (in D) and by direction (WTR or ATR).

By refraction, the values of POA were not normally distributed (skewed), so, square roots may be used. If also abnormally distributed, Mann Whitney method was used (using the median instead of the mean). The median of POA of phaco group was 1.00 (range from 0.50 to 1.50 D), compared with 3.25 (range from 1.50 to 5.50 D) at the 8th postoperative week in ECCE group. This correlation was highly significant; P. value was 0.00 (Table 10). Ohrloff C in Germany found the same results. Yi D H and Sullivan B R, from Dallas, stated that phaco had significantly less
postoperative astigmatism even in advanced cataract. Similarly, Heslin K B and Guerriero P N found that phaco averaged less postoperative astigmatism. In this study, the significance decreased after removal of sutures; P. value was 0.03, which showed the effect of sutures removal on reduction of POA (Table 11). Morlet et al proved that removal of sutures in the plus cylinder is an effective method for correction of POA. Kronish J W and Forster R K studied the effect of removal of sutures in Miami, the number of sutures cut during the sixth week after surgery was based on the degree of astigmatism; 0.00 to 2.00 diopters (D), no sutures cut; 2.25 to 3.00 D, one suture cut; 3.25 to 4.00 D, two sutures cut; greater than or equal to 4.25 D, three sutures cut. Their analysis demonstrated the following: (1) a spontaneous reduction of 0.5 D in surgically induced astigmatism in eyes without suture cutting, (2) an additional reduction of 1.2 D in postoperative astigmatism for each suture cut, and (3) attainment of 75% to 93% of the total effect of suture cutting within four weeks. Giers U and Pillunat LE from Germany, found that, if only one suture was dissected, the reduction in astigmatism amounted 1.75 D (mean), if two sutures were released the effect was 2.5 D, three or more
dissected sutures lead to a 3.4 D reduction in corneal astigmatism. The difference in the amount of reduction by removal of sutures may be due to other factors; like age, race or surgeon factors. Moreover, they noticed that the amount of astigmatism differed according to the time of suture cutting. The reduction in astigmatism amounts 2.25 D up to 8 weeks, occasionally 2.5 D 8-10 and 11-16 weeks after surgery, and 1.75 D up to 20 weeks thereafter (mean values). They concluded that, the longer the interval the more sutures had to be released. (63) Selective suture cutting is an interesting technique for an individual dosage of the amount of final astigmatism, stated by Andenmatten R, Balmer A and Hiroz CA, from france. (64)

There were no differences between phaco with foldable IOL and phaco with small diameter IOL regarding the degree of POA (P. value 0.29) (Table 12).

**Stability of refraction:**

In phaco group, refraction was stable after the 4th week, while in LI ECCE group refraction was still changing at the 8th week (Tables 8,9). Early visual recovery is one of the important advantages of small incision surgery, and glasses can be
prescribed at the 4th week, if needed. This corresponded with that mentioned in the literature. (39) Topographic analysis, which was done by Hayashi K, Nakao F and Hayashi F, demonstrated that phaco produced less corneal steeping and stabilized more rapidly than LIECCE. (65) Same result found by Heslin K B and Guerriero P N, the patients in the phaco group required less time for refraction to stabilize. (59) In the Auckland Cataract Study, although corneal astigmatism was eliminated in approximately half of the subjects 1 month postoperatively, astigmatism showed a tendency to regress towards the preoperative level with local corneal thickening at the site of incision 2 years after cataract surgery. (66)

**Postoperative complications:**

Few postoperative complications were noticed in the study population. The most prominent one was PCO, the incidence of which was slightly better in phaco group (8%) than LIECCE group (10%) (Table 40). Minassiana D C et al, found significant difference in the incidence of PCO, 5% versus 9%. (55) Other factors; like age, race, type of IOL, study sample and surgeon, may be responsible to this difference. Their sample size (500 patients) was larger than ours.
Surgically induced astigmatism (SIA) measured by keratometer:

Changes occurred in the corneal curvature postoperatively, this demonstrates the effect of surgery, and that both phaco and LI ECCE induced POA (Table 13,14) Same observation was mentioned by Dam J M and Olsen T.\(^{(67)}\)

LI ECCE induced POA (1.56 ± 1.6D) more than phaco surgery (0.68 ± 1.01); the relation was highly significant (Table 15). Similarly, Muller Jensen K, Barlinn B and Zimmerman H compared the effect of phaco on astigmatism using a 4.0 mm, no-stitch, clear corneal incision with that of (ECCE) using a 12.0 mm, sutured, clear corneal incision. Median surgically induced cylinder was 1.00 diopter (D) (range: 0.56 to 1.50 D) in the 4.0 mm no-stitch incision group and 1.75 D (range: 1.00 to 2.62 D) in the 12.0 mm sutured incision group.\(^{(68)}\) Their results were slightly higher than ours, the reason might be that they used clear corneal incision which is known to induce more POA than limbal incision.\(^{(7)}\) Kraff M C and
Sanders D R observed that phaco procedure averaged 0.27D less cylinder per case than the ECCE procedure. \(^{(69)}\)

Dam J M and Olsen T concluded that, phaco improves the surgical control of refractive outcome of cataract surgery. In their study, the mean of SIA was 0.91 D and 1.36 D in phaco and LI ECCE group, respectively. \(^{(67)}\) Although, phaco patients with small diameter IOL seemed to have SIA \((0.73 \pm 1.20 \text{ D})\) more than patients with foldable IOL \((0.58 \pm 0.42 \text{ D})\), this was not statistically significant \((P. \text{ value } 0.49)\) (Table 16). These results can be explained by that; almost all patients who had LI ECCE \((99\%)\), had incision > 7mm, while in phaco patients 66% had >5-7mm and 34% had 3-5mm (Table 2). In addition to that, most of phaco patients had sutureless wounds \((78\%)\), while \((97\%)\) of LI ECCE had 3 stitches or more (Table 3). Furthermore, all sutured incisions were interrupted \((100\% \text{ in LI ECCE, and only } 22\% \text{ in phaco})\), while \((78\%)\) of phaco patients had sutureless incisions (Figure 12). Lastly, the differences between phaco with small diameter IOL and phaco with foldable IOL, regarding the wound size and number of stitches, were not so much if compared with differences between each group of phaco and LI ECCE.
**Site of incision:**

Limbal incision was conducted in all patients of phaco and (99%) of LI ECCE; it is easier to perform, of rapid healing and less astigmatism. In the remainder 1%, post Limbal incision was done which in spite of its least risk of postoperative astigmatism was not routinely performed in this hospital. Anders N from Berlin, Germany, proved that limbal incision induced POA more than scleral incision. In addition to that, they found temporal were better than 12 o’clock incisions.\(^{70}\) Claoue C and Hicks C, in Moorfields Hospital, London, England, compared three incisions using phaco and conventional corneal section extracapsular cataract extraction; they found that, patients who had small and scleral incisions had better uncorrected visual acuities 6 weeks postoperatively because they had less astigmatism.\(^{60}\) Corneal incision in which there is no bleeding and the wound can be proved to be watertight, but it has a relatively high postoperative astigmatism and stable refraction is dependent on sutures.\(^{(2),(7),(69)}\) Andenmatten R, Balmer A, Hiroz CA, from France, studied 1304 patients; they found that corneal incision gave
significantly more against-the-rule astigmatism (average -0.61 D) than limbal incision (average -0.32 D).\(^{(64)}\) In contrast to that, Bilinska A, and et al, compared 3 groups of phaco; 1\(^{st}\) group scleral tunnel incision enlarged to 6 mm with continuous cross-like suture at 12 o’clock; In 2nd group with 3.2 mm scleral incision without suture at 12 o’clock; In 3rd group with 3.2 mm superotemporal incision in clear cornea, no suture. They found that lowest mean postoperative corneal astigmatism was achieved in group III.\(^{(71)}\) It might not be representative, they studied only 30 patients. However, Guirao A, Tejedor J and Artal P, from Spain, stated that, the incision site plays a main role in the corneal changes after surgery.\(^{(72)}\)

**Wound size:**

Apart from the site, size of incision plays a considerable role in the development of postoperative astigmatism. LI ECCE requires a large incision. Extent of the incision ranged between 10 –14 mm depending on the size of the nucleus of the cataractous lens. Smaller incisions are associated with less surgically induced change in corneal contour, a more stable refraction, earlier visual recovery, and a better uncorrected visual acuity, particularly early after surgery.\(^{(7)}, (59), (73)\)
Wound size corresponded to the type of IOL; foldable IOL had 3-5mm incision, small diameter IOL had >5-7mm incision and standard PMMA IOL had >7mm incision. SIA was not significantly influenced by the wound size, in phaco and LI ECCE, each group separately (table 17,18). The two groups were mixed (pooled), to compare the effect of wound size regardless of the type of surgery. The correlation that the larger the wound size, the greater SIA, was highly significant (P. value 0.00) (table 19). Post Hoc tests demonstrated that, the correlation was significant when comparing >7mm incision with 3-5mm and >5-7mm incisions. Comparison between 3-5mm and >5-7mm incisions was negative. Liu Yand Li S from china, studied the relation between the wound size and SIA; in phaco through a 6.5 mm limbal incision compared with that in ECCE through a 11 mm limbal incision. They concluded that reducing incision could minimize surgically induced astigmatism. (57) Vazquez L A and Panesso J L studied SIA by different wound size, significant differences were found between 9 mm and 6 mm incision in the early postoperative period. (52) Muller-Jensen K, Barlinn B and Zimmerman H studied phaco with a 4.0 mm no-stitch incision, and ECCE using a 12.0 mm sutured corneal incision. SIA was
statistically significant higher in ECCE group. (68) Same conclusion was proved by Lindstrom R L and Destro M A. (37) El-Kasaby HT, McDonnell PJ and Deutsch J fixed the wound size, sutured one group and the other left unsutured. The 6 mm scleral pocket incisions induce a small amount of astigmatism whether sutured or unsutured. (74) El-Maghraby A et al compared 3.5 mm with 5.5 and 6.5 mm incisions. The 3.5 mm incision cases had significantly less total keratometric cylinder than other cases at all postoperative examinations. (75) Same result was obtained by Martin RG et al. (76) This result was different from our study; no difference was observed between 3-5 mm and >5-7 mm incisions. The scleral incisions used might be responsible of this difference.

**Mode of suturing:**

Regarding the mode of suturing, 78% of incisions were sutureless in phaco group, while the remaining 22% had interrupted pattern. All patients of LI ECCE were closed with interrupted sutures. Interrupted pattern is known to induce more astigmatism when compared with continuous pattern. Interrupted sutures offer the advantages of more tension control for each bite, more wound security, selective suture removal postoperatively and the ability to
rotate and bury knots. The running suture technique offers the advantage of speed and more equal distribution of tension, which may decrease astigmatism. (7), (49) Postoperative astigmatism was studied in relation to mode of suturing, the study showed high significant correlation, that interrupted sutures induced more POA than sutureless incisions; after mixing the two groups and studying the mode of suturing regardless of the type of surgery (P. value 0.00) (Tables 23). Surprisingly, this correlation was not significant in phaco group alone. We can conclude that, wound size and number of stitches were the major causes of POA in this study. El-Kasaby H T, Mc Donnell P J and Deutsch J when fixed the wound size; 6 mm, incisions induced a small amount of astigmatism whether sutured or unsutured. However, they felt it was perhaps safer to suture an incision of that size. (74)

**Number of stitches:**

The relation between SIA and number of stitches was not significant in each group separately. But after pooling, highly significant correlation was found between number of stitches and SIA (P. value 0.00) (table 20,21,22). The relation was positive mainly when comparing no stitch with 3-4 stitches. Seventy eight
percent of phaco group had no stitch, while 94% of LI ECCE group had 3-4 stitches. Reading V M explained that the smaller changes in corneal curvature, found in phaco group, are attributable to the smaller incision size and reduced number of sutures. Andenmatten R, Balmer A and Hiroz C A found that, the suture induced astigmatism has no determining effect on the final astigmatism after 2 years.

All sutured wounds were sutured using Nylon. Nylon sutures are known to induce WTR astigmatism in the meridian of incision, which may explain the tendency of LI ECCE group towards WTR astigmatism initially. As sutures decayed, astigmatism shifted towards ATR. While phaco patients had ATR more than WTR astigmatism. This relation increased with time (Figure 15,16,17,18). Gimbel H V, Raanan M G and DeLuca M, in Alberta; Canada, compared the use of 10-0 Nylon, 10-0 Polypropylene (Prolene), 11-0 Polyester (Mersilene), and 10-0 Polyethylene (Novafil) suture materials on the amount and decay curves of surgically induced astigmatism following intraocular lens (IOL) surgery. Patients with Mersilene and Nylon sutures had the highest amounts of induced with-the-rule (WTR) cylinder (significantly more than Prolene) at one
day after surgery. However, the WTR cylinder decayed rapidly for Nylon during the first three months. The Nylon group had the second highest amount of induced WTR cylinder at one day, which had decayed to ATR cylinder by five months. Between one and two years postoperatively, the Nylon group experienced a significant ATR shift. The amount of early induced WTR cylinder seemed to be related to the knot-tying technique and tissue gripping characteristics, whereas the shape of the decay curve was related to the material characteristics of the suture. (77)

The operated eye:

Another observation that, right eyes had more SIA than left eyes in each group. It might be only by chance, statistically no significant correlation was found; in each group separately or after pooling (Tables 24, 25).

Types of SIA:

Phaco was found to induce slightly more ATR astigmatism (50%) compared with LI ECCE (47%), while LI ECCE had more WTR astigmatism (46%) compared with phaco (35%). These relations were not statistically significant (Table 26). It is obvious that refraction was not coinciding with keratometry. The difference
between refraction and keratometery may be due to that refraction is affected by the clarity of visual media and its refractive index. Also, refraction is more subjective than keratometery. Moreover, preoperative refraction was neglected in this study, because most patients had faint or even no fundal reflex. Kronish J W and Forster R K demonstrated a strong correlation between the keratometric and subjective refractive measurements during all postoperative examinations, which indicated that corneal astigmatism is primarily responsible for postoperative astigmatism. (62) This may be due to early presentation of their patients, so refraction is clear and valuable.

As a general rule, phaco induced ATR astigmatism more than LI ECCE at every time in this study (Figure 17,18). Reading V M found that ATR predominated after one year, in both groups. (73) The same was found in this study after 2 months. This may be due to the rapid decay of Nylon suture. (77) Hennig A et al reached the same conclusion, that sutureless cataract surgery led to an increase in ATR astigmatism. (78) Rao S N et al used these facts to treat preexisting ATR astigmatism, by making 5.5 mm temporal clear
corneal incision; in the axis of the plus cylinder, statistically significant reduction in astigmatism was observed. (79)

**Period of steroid use:**

Most patients; (97%) of phaco and (95%) of LI ECCE, used steroid for one month postoperatively. So, the effect of the period of steroid use in the type or degree of SIA, was not observed (Table 33,34,35,36,37). Prolonged use of corticosteroids in selected cases may allow greater wound slippage to help treat pre-existing WTR astigmatism. Likewise, a short course of postoperative corticosteroids may help to minimize astigmatic decay from a superior scleral pocket incision in a patient who has preoperative ATR astigmatism. (7) Barba K R, Samy A, Lai C, Perlman J I and Bouchard C S studied the effect of steroid on wound healing in 9 cats. They found that the steroid-treated corneae had less wound healing than untreated or NSAID-treated corneae. (80) Masket S compared the effect of topical steroid with topical NSAIDs in 6.5 mm scleral pocket incision. The incisions were closed with a continuous running 10-0 monofilament nylon suture. Both agents demonstrated similar postsurgical astigmatic decay curves; however, the group receiving the nonsteroidal agent had an earlier decay of
iatrogenically induced astigmatism. But 20% of NSAIDs group had needed to add steroid in the postoperative course.\textsuperscript{(81)}
CONCLUSION

The present study with its limitations has highlighted the following:

- Phaco had better BCV postoperatively than ECCE, but not after removal of sutures.
- POA had been found in ECCE group was, significantly, higher than phaco; when refraction was checked at 8th postoperative week, but no significant differences was recorded after removal of sutures.
- Removal of sutures decreased POA and improved vision of ECCE PCIOL patients.
- Refraction of phaco patients was stable at 4th week, while still changing in ECCE PCIOL patients at the 8th postoperative week. Stability of refraction was earlier in phaco than large incision group.
- Phaco induced more ATR astigmatism, while ECCE PCIOL induced more WTR
astigmatism, but it shifted toward ATR with time in ECCE PCIOL.

- SIA was lesser in phaco patients than ECCE PCIOL patients, while there were no differences between phaco with foldable IOL and phaco with small diameter IOL.
- Larger wound incision (>7mm) caused more SIA than smaller incisions (3-5 and >5-7mm).
- ECCE PCIOL with 3-4 stitches had higher incidence of SIA than sutureless phaco.
- No difference was observed between phaco with foldable IOL compared with phaco with small diameter IOL regarding SIA in relation to the wound size or number of stitches.
- Regarding SIA, sutureless cataract surgery had more favourable outcome.
- SIA was nearly similar in each of the operated eyes (right or left).
- Type of SIA was not significantly different between the two groups; phaco and ECCE PCIOL. Furthermore, it was not affected by the wound size, number of stitches or period of steroid use.
RECOMMENDATIONS

1. Small incision cataract surgery should be encouraged in our country to reach higher standards of visual outcome.

2. Training of resident registrars to perform phaco surgery, as it needs along course of training.

3. Cataract surgery is a refractive surgery. Its aims should not be limited to removal of cataractous lens and correction of spherical errors. Astigmatic errors can be controlled successfully during surgery.

4. Site of incision, suturing, Terry keratometer and other methods are easy, cheap and useful solutions to treat preexisting astigmatism, or to avoid marked POA.

5. Surgeons should not hurry to correct SIA before 12th week, as astigmatism tends to change with time. Only removal of sutures in
the meridian of the plus cylinder may be the solution.

6. Keratometry is a simple method that should be carried routinely for every patient postoperatively. This will enable surgeons to study the ultimate SIA and hence improve their surgical techniques.

7. Small diameter IOL patients achieved nearly same results as patients with foldable IOL in phaco group. It may be used to decrease the cost of phaco surgery.

8. Further studies should be carried to determine the long-term effect of cataract surgery regarding SIA, as some centers showed that no difference was recorded between various types of surgery after 2 years.

9. The effect of suture material and removal of sutures on POA may need further studies. In this study, surgeons used only one type of
suture and we couldn’t study the relation between the number of sutures removed and the reduction of POA after removal of sutures.
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University of Khartoum
Postgraduate Medical Studies Board
Questionnaire
Astigmatism following phacoemulsification
Versus large incision E C CE with I O L Implantation

Serial Number: --------- O.T Number: ---------
Name: ------------------------------- Sex: ---------------- Age: ---------
Residence -------------------------- Tel -------------------------
C/O -------------------------------- Date of operation: -----------------
Operated Eye: ( R ) [ ] ( L ) [ ]

Pre-Operative Ocular Examination:

<table>
<thead>
<tr>
<th>Sr.</th>
<th>V. A</th>
<th>Refraction</th>
<th>B.C.V.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
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<thead>
<tr>
<th>Sr.</th>
<th>Eye lids</th>
<th>Conjunctiva</th>
<th>Cornea</th>
<th>Iris</th>
<th>Pupil</th>
<th>Lens</th>
<th>Fundus</th>
<th>IOP</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
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Keratometry

<table>
<thead>
<tr>
<th>Sr.</th>
<th>Keratometry V</th>
<th>H</th>
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<tbody>
<tr>
<td>1</td>
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<td></td>
</tr>
<tr>
<td>2</td>
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Power Of IOL

Aetiology of Cataract:

<table>
<thead>
<tr>
<th>Sr.</th>
<th>Senile [ ]</th>
<th>Traumatic [ ]</th>
<th>Congential [ ]</th>
</tr>
</thead>
<tbody>
<tr>
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</table>

Type of surgery:

<table>
<thead>
<tr>
<th>Sr.</th>
<th>Phaco [ ]</th>
<th>Large incision [ ]</th>
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Anaesthesia:

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<tr>
<th>Sr.</th>
<th>Topical [ ]</th>
<th>Local [ ]</th>
<th>General [ ]</th>
</tr>
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<tbody>
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</table>

Site of incision:

<table>
<thead>
<tr>
<th>Sr.</th>
<th>Scleral [ ]</th>
<th>Limbal [ ]</th>
<th>Corneal [ ]</th>
</tr>
</thead>
<tbody>
<tr>
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</table>

Wound size in mm:

<table>
<thead>
<tr>
<th>Sr.</th>
<th>3.0 – 5.0 [ ]</th>
<th>&gt; 5.0 – 7.0 [ ]</th>
<th>&gt; 7.0 [ ]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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</table>

Mode of suturing:

<table>
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<tr>
<th>Sr.</th>
<th>interrupted [ ]</th>
<th>continuous [ ]</th>
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</tbody>
</table>

Number of stitches:

<table>
<thead>
<tr>
<th>Sr.</th>
<th>0 [ ]</th>
<th>1 – 2 [ ]</th>
<th>3 – 4 [ ]</th>
<th>&gt; 4 [ ]</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>

Size of suture material:

<table>
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<tr>
<th>Sr.</th>
<th>8/0 [ ]</th>
<th>10/0 [ ]</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
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</tbody>
</table>

Type of suture:

<table>
<thead>
<tr>
<th>Sr.</th>
<th>Prolene [ ]</th>
<th>Nylon [ ]</th>
<th>Vicryl [ ]</th>
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</thead>
<tbody>
<tr>
<td>1</td>
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<td></td>
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</tbody>
</table>

Type of IOL:

<table>
<thead>
<tr>
<th>Sr.</th>
<th>Standard PMMA [ ]</th>
<th>Foldable [ ]</th>
<th>Small D I A [ ]</th>
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</thead>
<tbody>
<tr>
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<td></td>
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</table>

Site of I O L implantation:

<table>
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<th>Sr.</th>
<th>A/C [ ]</th>
<th>P/C [ ]</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>
Postoperative follow up:

(A) First postoperative follow up: (3-7 days after surgery)

- Wound closure: Sealed [ ] Gap [ ] Iris Prolapse [ ]
- Vit. incarceration [ ]
- Suturing: Tight [ ] Loose [ ] Broken [ ] Normal [ ]
- Pupil: Regular [ ] Distorted [ ]
- Position of I O L: In place [ ] Dislocated [ ] Decentered [ ]
- Posterior Capsule: Intact [ ] Hole [ ] Ruptured [ ]

(B) The second postoperative follow up: (Four weeks after surgery)

Before R.O.S.

<table>
<thead>
<tr>
<th>V.A.</th>
<th>B.C.V.</th>
<th>Ref</th>
</tr>
</thead>
</table>

Type of postoperative astigmatism: Irregular [ ]
Regular: WTR [ ] ATR[ ] Neutral[ ] Unclear[ ]

(C) The third postoperative follow up: (Eight weeks after surgery)

Before R.O.S.

<table>
<thead>
<tr>
<th>V.A.</th>
<th>B.C.V.</th>
<th>Ref</th>
</tr>
</thead>
</table>

Type of postoperative astigmatism: Irregular [ ]
Regular: WTR [ ] ATR[ ] Neutral[ ] Unclear[ ]
I O L position: In place [ ] Sunset synd. [ ] Sunrise synd.[ ] Decentered [ ]
Wound closure: Sealed [ ] Defective [ ]
Suture reaction: Yes [ ] No [ ]
Period of steroid usage: ------------------------------------------
Other complications: (mention)-------------------------------------
Others: ----------------------------------------------------------

(D) After removal of sutures: (Ten weeks after surgery)

After R.O.S.

<table>
<thead>
<tr>
<th>V.A.</th>
<th>B.C.V.</th>
<th>Ref</th>
</tr>
</thead>
</table>

Type of postoperative astigmatism: Irregular [ ]
Regular: WTR [ ] ATR[ ] Neutral[ ] Unclear[ ]
Keratometry V-------------------------------------------- H-------------------------------------