"COMPARATIVE STUDY BETWEEN DIRECT CHOP AND STOP AND CHOP IN PHACOEMULSIFICATION SURGERY OF GRADE III-IV NUCLEAR SCLEROSIS IN PATIENTS ADMITTED IN KLE'S DR.PRABHAKAR KORE HOSPITAL AND MEDICAL RESEARCH CENTRE BELAGAVI: ONE YEAR RANDOMISED CONTROL STUDY"

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Seal & Signature of the HOD

Dr. ARVIND L.TENAGI **MS(ophtho),FGO**
Professor& Head,
Department of Ophthalmology,
J.N. Medical College,
Belagavi – 590010.
Karnataka, India.

Date :

Seal & Signature of the Principal

Dr. (Mrs.) N. S. Mahantashetti **MD (Paed)**
Principal,
J. N. Medical College,
Nehru Nagar,
Belagavi - 590010.
Karnataka, India.

Date :

ACCEPTANCE LETTER

KLE
JAWAHARLAL NEHRU MEDICAL COLLEGE
[Recognized by Medical Council of India, New Delhi]
Accredited 'A' Grade by NAAC (2nd Cycle) Placed in Category 'A' by MHRD (GoI)
Nehru Nagar, Belagavi- 590 010, Karnataka, INDIA
0831 - 2471350 0831 - 2470759 www.jnmc.edu principal@jnmc.edu

Ref No: MDC/PG/ Date: 11-09-2020

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Dr. (Mrs.) N.S. Mahantashetti.
Chairperson-Antiplagiarism Committee &
Principal,
J. N. Medical College, Belagavi.

To,
Reg. No. BK0118003.
Postgraduate Student,
2018-19 Batch,
Department of Ophthalmology,
J. N. Medical College, Belagavi.

LIST OF ABBREVIATIONS USED

AC-IOL	Anterior Chamber Intraocular Lens
BCVA	Best Corrected Visual Acuity
CCC	Continuous Curvilinear Capsulorrhexis
CDE	Cumulative Dissipated Energy
CNS	Central Nervous System
D	Diopter
ECCE	Extracapsular Cataract Extraction
ICCE	Intracapsular Cataract Extraction
IOL	Intraocular Lens
LASIK	Laser In Situ Keratomileusis
PC -IOL	Posterior Chamber Intraocular Lens
PMMA	Polymethylmethacylate
SICS	Small Incision Cataract Surgery

ABSTRACT

Background and objectives

Visual impairment has emerged as a potential debility affecting almost 285 million people around the world. WHO in the year 2007 has reported the contribution of cataract to global blindness as 39%.

There has been so much evolution in the field of cataract surgery from 600 BC to the current time. The surgeons have been a witness to remarkable evolution in the techniques involved in cataract surgery in the 20th century like couching (600 BC) and ICCE (1973). Due to the non-curable complications associated, they have become obsolete. The emergence of phacoemulsification by Dr.CharlesKelman in 1967 is regarded as a major milestone in the field of cataract surgery.

The successful management of a cataract surgery by phacoemulsification depends on various factors and a pivotal element is the firmness or brunescence of the lens. Even experienced surgeons view phacoemulsification in hard cataracts as challenge.As the hardness of nucleus increase with maturation the procedure of phacoemulsification becomes more difficult.

Various techniques have been described for the nuclear management in phacoemulsification like,divide and conquer,stop and chop,direct chop,retro chop etc.Among these stop and chop and direct chop are quite popular. Only a few articles compare the direct chop and stop and chop techniques using various parameters. In this study, we compare the efficacy and safety of the two techniques prospectively.

- To evaluate the safety and efficacy of two surgical techniques: directchop and stopandchop in phacoemulsification of grade III-IV nuclear sclerosis

Methodology

The present study was conducted at the Department of Ophthalmology, KLE'S Dr.Prabhakar Kore Hospital and Medical Research Centre, Belagavi during the study period, from 1st January 2019 to 31st December 2019 and 96 patients were enrolled. It included patients who were diagnosed with grade III-IV nuclear sclerosis and willing for phacoemulsification with PCIOL implantation, meeting the inclusion criteria. There were assigned to either of the two surgical techniques by computer generated random numbering system. Group A patients underwent Phacoemulsification with DirectChop Technique whereas, Group B patients had Phacoemulsification with StopandChop Technique. Intraoperatively phaco parameters as well as complications noted. Postoperatively, they were evaluated at Day 1 ,1 week and 4 weeks.

Results

In the present study, the mean age in Group A was 67.60 ± 9.11 years and Group B was 63.17 ± 8.39 years and majority of the patients belonged to the range of 61-70 years.In the present study, 64.58% were male and 41.67% were female with male: female ratio of 1.54:1 in Group A. 35.42% were male and 58.33% were female with male: female ratio of 0.6:1 in group B.

In the present study, pre-operative visual acuity in the range of >6/60 was seen in 20.83% (10) patients, 6/60 to CF 1 ½ M in 37.50 % (18) patients and CF1M to PL+,PR-ACC in 41.67 % (20) patients Of Group B. In group A, there was an equal distribution of patients, that is,33.33%(16 patients) in all the above three categories.

In this study,39 patients (81.25%) in the Group A and 37 patients(77.08%) in the Group B had a nuclear grading of -Grade III. 9 patients (18.75%) in Group A and 11 patients(22.91%) in Group B had a nuclear grading of -Grade IV.

The mean effective phaco time in Group A was 7.36±3.43 sec and in Group B was 8.67±5.52 sec(p-<0.16) and the mean phaco power(%) in Group A was 8.61±2.87 % and in Group B 8.67±5.52 sec(p-<0.16. In this study, intraoperative aspiration fluid required in Group A 177.60±20.78 ml and in Group B was 173.96±52.95 ml(p-0.65). None of these parameters were statistically significant on comparison.

At 4 weeks post-operatively, both Group A and B had 97.92% (47) patients with visual acuity ranging from 6/6-6/12.There was no significant difference between the two groups (P value- 1.0000).

Conclusion and interpretation

There existed no significant difference between the direct chop and stop and chop group when you compare the intraoperative and post-operative parameters. Hence proving both the methods are equally efficacious for nuclear management in hard cataracts. Eventually, the individual surgeon must choose his or her own approach for phacoemulsification in hard cataract.

Keywords:Phacoemulsification,hard cataract,stopand chop,directchop

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INTRODUCTION

Visual impairment has emerged as a potential debility affecting almost 285 million people around the world.[1] The estimates show that around 68% people who fall above 79 years have developed opacification of lens.[2] WHO in the year 2007 has reported the contribution of cataract to global blindness as 39%.[3]

There has been so much evolution in the field of cataract surgery from 600 BC to the current time. The surgeons have been a witness to remarkable evolution in the techniques involved in cataract surgery in the 20th century like couching (600 BC) and ICCE (1973). Due to the non-curable complications associated, they have become obsolete.[4,5]

Intracapsular Cataract Extraction: In 1753, Samuel Sharp performed the first documented intracapsular cataract extraction (ICCE)[6].Larger incision along with slow healing , high surgical astigmatism ,endothelial decompensation, and cystoid macular edema are some major complications noted.[7]

Extracapsular cataract extraction: The procedure which dates back to as early as 600 BC when an Indian surgeon, Sushhruta may have been the first one to perform it. Although this procedure represented great progresscompared to couching, postoperative complications were considerable, including poor wound healing, increased post-operative astigmatism, retained lens remnants, posterior capsular opacification, and infection. Overtime the techniques have improved and overall success rate is now 90-95%[7]

The emergence of phacoemulsification by Dr.CharlesKelman in 1967 is regarded as a major milestone in the field of cataract surgery.

The current era saw major developments in the field of cataract surgery in terms of technology, size of incision, energy expenditure, post -operative complication and efficiency ,which has increased tremendously [8.] Phacoemulsification together with implantation of IOL is the main technique involved in the treatment and when conducted under local anaesthesia is superior to extracapsular cataract extraction.[9]

Phacoemulsification is easier to perform in grade II-III nuclei where not much ultrasound energy is required too emulsify the cataractous lens. These become more difficult with dense cataracts like the grade IV as well as the mature ones.

Among various grades of cataract, hard cataracts represent advanced stage of maturity, where the nuclei are highly dense and the anatomic support structures, including the capsule and zonular fibers, which are worn out, weak and friable and the surrounding structures are unavailable to withstand the effects following a surgery at this stage. It is quite challenging from the view point of a phacoemulsification surgeon.[10]

Experimentations worldwide have been fruitful and many techniques in phacoemulsification have been described. The primary objective is to come up with the technology that will transfer minimal stress on to the zonules and help in reducing the amount of ultrasound energy and total ultrasound time during phacoemulsification surgery.[11]

The first one to describe the nucleofractis technique was Gimbel[12]. He named it the divide and conquernulceofractis. From that time, many variations in the division of nucleus was discussed, like the direct chop and stop and chop. Several modifications like horizontal and vertical chop have also come up[13–15]. Each have a very unique and distinct advantage and are popular with the surgeons.

Among the various techniques described direct chop and stop and chop are the most popular. The procedure involves mechanical fragmentation of the nucleus into small segments with the aid of a special instrument called as the chopper. The factor which differentiate the direct chop and stop and chop is the creation of a central groove at the beginning of the stop and chop technique. This step even though results in larger energy consumption , aids the surgeon in cracking the hard posterior plate, thus facilitating the procedure.[16]

Only a few articles compare the direct chop and stop and chop techniques using various parameters. In this study, we compare the efficacy and safety of the two techniques.

OBJECTIVES

To evaluate the safety and efficacy of two surgical techniques :direct chop and stop and chop in phacoemulsification of grade III-IV Nuclear sclerosis

REVIEW OF LITERATURE

The term cataract is derived from the Latin cataracta and from the Greek katarraktes which denotes a waterfall or a portcullis. Analogously a "cataract is a complete or partial opacification of sufficient severity, on or in the human lens or capsule, to impair vision(17)". Cataract is defined as an "An opacity, congenital or acquired, in the lens capsule or its substance due to irreversibly coagulated proteins.(7)

Prevalence:

Various studies like the Rapid Assessment of Avoidable blindness survey and 2010 global burden of Diseases, Injuries And Risk Factors Study have chipped in lot of significant information regarding our knowledge of the cataract burden.(18) In 2010,the numbers went up to reach 20 million, with a range of 12.7% in North America and 42.0 % in South east Asia.

In the past decade the prevalence rate fell in the Eastern Asian and west European areas and now the highest prevalence is seen in the Sub-Saharan Africa with 6.0% rate in the western region and 5.7% in the eastern periphery.(19) The decline in prevalence is mainly attributed to the increased cataract surgical rates globally (20,21).

Sex and socioeconomic levels also said to have a role in its higher prevalence rate and late presentation for treatment. Many studies have concluded that women have a higher rate of cataract than men. The age-standardized prevalence of cataract blindness in 2010 was 0.19% for women and 0.13% for men(22) .Many theories have been put forward as explanation for the same. One theory is that the life expectancy in

females are longer where as another suggested that the women being less vocal regarding their health issues and might end up with mature cataract in many cases. The first theory was investigated by controlling for age and found that women still had higher cataract rates than men .(23)

CLASSIFICATION OF CATARACT

A classification for immature cataract was given by Duke-Elder(24),who classified it into the following groups:

1. Nuclear

2. Cortical

a. Cuneiform

b. Perinuclear

c. Cupuliform

Cuneiform: These are wedge shaped opacities extending radially towards anterior pole of lens. With time they increase in size and extend to involve the whole cortex.

Intumescent cataract: It is a potential stage during the course of maturation of cortical cataract, in which lens get swollen up due to imbibition of fluid.

Perinuclear variety of cortical cataract: it is distinguished by the presence of multiple pinpoints like opacities in the deeper cortex, which eventually forms a ring around adult nucleus

Cupuliform cataract: They are usually seen in conjunction with nuclear sclerosis and is marked by the presence of a localized posterior subcapsular opacity

For epidemiological study and follow up, the classification of cataract was done by evaluation of the changes in lens colour, noting done the position of lenticular opacity and documenting the clinical photographs

A classification was recommended by The American Cooperative Cataract Research Group (CCRG) based on the stereoscopic colour photographs of excised human lenses. Here, six stereoscopic views of the lens are documented and the colour changes are employed in a distinct way. A semiquantitative description of the extent of opacities was made.

The following classification was developed consequently:

1. *Hyper mature (H)* A totally opaque lens, that has undergone a marked anteroposterior swelling.
2. *Mature (M)* A totally opaque lens with no recognizable anatomical zone swelling.
3. *Immature cataracts* These possess some amount of normal lens anatomy. It can be subclassified as:

a. Anterior subcapsular (SCA)

b. Posterior subcapsular (SCP)

c. Anterior cortex (CXA)

d. Equatorial cortex (CXE)

e. Posterior cortex (CXP)

f. Supranuclear (SN)

g. Nuclear (N).

Extent of subcapsular cataracts is graded by relating the opacity to a series of concentric circles, the outermost representing the equatorial circle of the lens. Each circle denotes a predetermined area of the lens shown in percentage of total area. The enface view of the lens is divided into 100 equal segments. By counting the number of segments involved, the extent of opacities is immediately calculated.

Classification schemes such as the Lens Opacities Classification System II(24) and III (25) (LOCS II and LOCS III), and the Age-Related Eye Diseases study (AREDS Manual of Operations, 1994) use photographic standards to subdivide each major type into grades.

The grading is based either on density and colour (nuclear) or according to the anatomic location of the cataract (cortical and posterior subcapsular). We can perform a direct comparison of the patient's lens as viewed by slit lamp with a photographic copy of the standard grading system or extract photographs of the lens being studied, and later do a photographic grading based on the classification systems. (26)

<u>Grading Of Nuclear sclerosis on Slit lamp Bio microscopy:</u>

Grade 1-Soft (greenish yellow)

Grade 2 – Soft-medium (Yellowish)

Grade 3- Medium Hard (Amber)

Grade 4 – Hard (Brown/black)

ETIOPATHOGENESIS OF CATARACT:

The progression of cataract is related with multifactorial and synergistic causes. (27)Age is one of the main culprits in the development of nuclear sclerosis and other forms of cataract.

As per the various epidemiological studies undertaken, the type and incidence differ around the world. In India for instance the ailment following cataract tends to mainly occur at the middle age and cortical is the main variety noticed as compared to nuclear or posterior subcapsular cataract.

Various factors have been implicated and are as follows:

A. Personal factors

B. Environmental factors

Personal Factors

Personal factors are (a) Age (b) Systemic disorders (c) Ocular conditions (d) Dietary factors

Age: Age related cataract are a cumulative effect of various changes taking place at the genetic expression level and many environmental factors. An event linked with the growing age is change in the colour of the lens nucleus. It is supplemented by the reduction in lens transmission. This is said to be due to the photochemical degradation of intrinsic lens tryptophan to N-formyl kynurenine by the action of free oxygen radicals. This assumption coincides with epidemiological results revealing significantly higher cataract extraction rates in areas of the USA where sunlight is

present for the longest time compared to areas with moderate climates and shorter sunlight duration.

The various alterations in the lens proteins are responsible for the changes in the physical characteristics of the lens. The main factor maintaining the transparency is the unique arrangement of lens proteins and the equilibrium maintained between the lens proteins and water content of the crystalline lens. Anything which disrupts this, osmotic or metabolic ,will result in the swelling of the lens. Besides, any structural changes in the protein itself can result in opacity formation. The changes in the lens protein can occur during its biosynthesis and this phase lasts only until lens fibre if formed.

With the loss of its nuclei mature lens fibre will cease the lens protein production. So, a second possibility in the lens protein changes is only by means of post translational modifications. With advancing age, there is occurrence of anaerobic glycolysis and this in turn affects the crucial energy dependent metabolic steps. This makes the lens more vulnerable to the endogenous and exogenous damaging influences and results in opacifications. Some important post translational modifications are deamidation, phosphorylation, glycosylation, formation of disulphide bonds and mixed disulphides, racemization of optical active parts, proteolysis, formation of aggregates, and oxidation of methionine. It is mainly anticipated to affect the oldest lens fibres. These structural changes can cause increased scattering of incident light due to protein conversion and aggregate formation.

Trauma: A penetrating injury is associated with rapid influx of fluid and resultant hydration of fibres leading to a localized opacity. A blunt injury however

does not produce any rupture of capsule and fluid influx results in a characterised flower shaped opacity at the anterior subcapsular region.

Electric shocks, ionizing radiations like Xray's and non-Ionizing radiations like infrared (glassblowers' cataract) can result in cataract.

Systemic disorders:

Diabetes Mellitus:The characteristic cataract seen in uncontrolled type 1 diabetes mellitus is snowflake cataract. When the blood glucose level increases, there occurs seeping in of glucose into the lens by diffusion There it is acted up on by aldose reductase enzyme to form sorbitol. This newly formed sorbitol cannot cross the cell membrane and will get cumulated within the lens fibres. This causes osmotic imbalance and to fix this water is taken up by the cell. This causes undue swelling of the lens fibres and they burst. This progress rapidly and the early lesions are mainly anterior and posterior subcapsular and cortical opacities.

The most important factor associated is the duration of diabetes mellitus. The mechanisms other than sorbitol accumulation which are involved are protein glycosylation, increased superoxide production in the mitochondria, and phase separation.

Galactosemia: Another enzymatic disorder associated with cataract is galactosemia. It is an autosomal recessive disorder and there is a deficiency of multiple enzymes involved in the conversion of galactose into glucose. Galactose 1-phosphate uridyltransferase galactosemia is characterized by with mental retardation, failure to thrive, and enlargement of liver and spleen. As the serum galactose level rise, it accumulates with the lens and causes an osmotic disturbance. In order to

correct it there will be water influx and it proceeds similar to diabetes. The removal of galactose from the diet can halt the advancement of the cataract. Galactokinase enzyme deficiency will present with cataract and galactosemia devoid of other systemic manifestations.

Myotonic dystrophy is an autosomal dominant disorder that involves the functioning of muscles. It results in wasting and inability to relax skeletal muscles. cataract is found to occur around the second decade and slowly worsens. Initially it will have polychromatic dots and flakes and later, it develops a characteristic 'Christmas tree' appearance. Other significant findings in the eye include blepharitis, altered pupillary responses and pigmentary retinopathy. These patients also develop intellectual disability, conduction defects and hypogonadism.

Fabry's disease is a rare inherited lysosomal storage disorder due to deficiency of enzyme alpha galactosidase. It causes accumulation of the glycosphingolipid, Ceramide trihexoside. The patient suffers from episodic fever, acroparesthesia, raised blood pressure, cardiomyopathy, kidney disease, and angiokeratomas. In the affected man and the carrier woman, a typical mild, "spoke-like," visually insignificant cataract develops. The affected individuals develop characteristic spoke-like cataract, which doesn't affect the visual status of the patient much.

Alport's syndrome is a genetic disorder causing nephropathy and hearing loss and ocular abnormalities. Ocular features include congenital or postnatal cortical cataract, anterior or posterior lenticonus, and microspherophakia.

Cockayne's syndrome: Deafness, dwarfism(disproportionate limbs),optic atrophy, retinal degeneration and cataract

Werner's syndrome: AR disorder characterized by diabetes mellitus, stunted growth, hypogonadism and cataract

Rothmund-Thompson syndrome: AR disorder associated with poikiloderma, hypogonadism, saddle-shaped nose, abnormal hair growth and cataracts

Atopic dermatitis: There can be a localized proliferation of lens epithelium in patients of atopy which can lead to bilateral, abruptly advancing dense anterior subcapsular plaque with cortical opacities radiating from it along with anterior capsular wrinkling termed Shield cataract.

Other dermatological conditions like ichthyosis (cuneiform cataract), incontinentia pigmenti (X linked) are also associated with cataract formation.(28)

Ocular conditions:

- Inflammatory uveits- Juvenile idiopathic arthritis, Fuch's heterochromic iridocyclitis
- Infective uveitis-Toxoplasmosis, syphilis, herpes zoster
- Retinal Pigment Degenerations-Retinitis pigmentosa, Usher's syndrome, gyrate atrophy
- Retinal detachment and retinal surgery-silicone oil
- Ciliary body tumours
- High myopia
- Anterior segment ischemia

Dietary factors:

Protein and amino acids: Epidemiological studies have shown an association between cataract and decreased protein intake. There are numerous reports confirming that a deficiency in tryptophan has resulted in cataract.

Vitamins: The vitamins E,C and riboflavin have been implied to have a role in the metabolism of lens fibres. Riboflvain is found to improvise the action of glutathione reductase enzyme and vitamins E and C are free radical scavengers.

Hypocalcaemia has been found to be interlinked with the formation of zonular cataract. Studies revealed low plasma levels of calcium in patients of senile cataract when compared with the control group. Other enzymes presumed to be involved in evolution of cataract are copper, zinc and selenium(29). However, ARDES study, conducted under the sponsorship of National eye institute USA which constituted of providing nutritional supplements (Vitamin C 500 mg, Vitamin E 400 IU, Beta-Carotene 15 mg, Zinc Oxide 80 mg, Cupric Oxide 2mg)for prevention of ARMD did not show any prevention of cataract or any slowing of its progression.

Dehydration*:* Studies have shown as association between dehydration crisis and senile cataract. The osmotic imbalance due to malnutrition and increase in levels of urea and ammonium cyanide in the blood are responsible for cataract formation. Ammonium cyanide can denature the lens proteins by the process of carbamylation.(30,31)

Environmental Factors

Role of Sunlight*:*Almost the entire electromagnetic spectrum radiation has cataractogenic potential on exposure. Exposure to a dose of 200 rads had been found to cause cataract. Even though various epidemiological studies have commented upon the role of sunlight in the process of cataract formation, the exact mechanism is still unknown. It is believed that the photo peroxidation of lens constituents causes free radial generation and thus lead to cataract formation.(32,33)

SEQUALAE OF CATARACT MATURATION

In the developing world, cataract is still a leading cause of blindness. Even though the developments that have taken place improved the cost effectiveness of the surgery, when a large population is affected, meeting all their requirements becomes difficult many a time and people present with denser cataracts, including the mature and hypermature. Though the proportion of people presenting with it has reduced, we still encounter varying degrees of hyper maturity in the upcoming middle-income countries.(34) It is also observed that, after cataract surgery of one eye, there is a general tendency to neglect the other eye, which can lead to maturation of the pre-existing cataract and lead to mature or hypermature cataract at a later date.

With the maturation of cataract there will be the process of lens fibre dissolution enzymatically which leads to the liquefaction and later get resorbed by the cortical fluid. The nucleus is not susceptible to this affair and will remain floating inside the capsular bag surrounded by the cortex which is in turn liquified.(35)There can also be seeping of the lenticular contents through an intact ,but permeable lens

capsule or through a minor deficiency in the anterior capsule into AC. These contents which reach anterior chamber can give rise to secondary glaucoma and uveitis. There can also be spontaneous dislocation of lens because of the zonular weakness. (36)

The normal lens capsule is a molecular mesh consisting of collagen, mainly type IV, laminin and fibronectin and these all together bind it and maintain its biochemical integrity(37).In case of a maturing cataract ,the lens fibres will imbibe fluid and get swelled up and may result in a spontaneous rupture of lens capsule. The ensuing picture will depend up on the characteristics of the rupture.(38)

Also the denser cataracts, like a Grade III or Grade IV nuclear sclerosis are associated with compact nuclear lens fibres which makes the separation difficult. So, breaking down the nucleus during phacoemulsification is time consuming and requires use of more ultrasound energy for the same.

There are many secluded reports of anterior lens capsule rupture in case of a mature cataract. Rarely, some cases have even gone for a spontaneous anterior dislocation of the nucleus. They were managed by nucleus removal using a Vectis.(38–40)

There are also cases of posterior capsular dehiscence noted which may or may not be associated with posterior dislocation of the lens. Any case of this kind was picked on B scan and associated vitritis was also seen.(41).This kind of dehiscence can result in spontaneous resorption of lens.(42)

Also, in the anterior capsule in a case of cataract which is reaching end stage of maturation, there can be calcification and increased laxity with capsular folds on the capsule. These two effects will make a capsulorrhexis difficult in these cases.

Also, the absence of the perinuclear plate will result in the nucleus being mobile and this might pose a danger during surgery. Also, the intraocular manoeuvres in case of a surgical procedure will be difficult due to a shallow AC which is seen with mature cataract.(43)

So timely diagnosis and prompt intervention is important as far as the management of a mature cataract is concerned and call of the hour is to spread awareness about the sight threatening complications of senile cataract among the developing nations.

Diagnosis calls for a clear background knowledge about the clinical features of the disease.Various features might be overlapping, however some are quite specific to cataract formation.

CLINICAL HISTORY: SIGNS AND SYMPTOMS

- **Decreased Visual Acuity:** Most of the patients present with gradual diminution of vision over a period of time. Some may not have noticed their visual debility until examined. This is noticed especially with unilateral cataract formation. The effect produced will vary depending on various factors like incident light, pupil size and refractive error.

- **Glare and altered contrast sensitivity:** Glare is one of the earliest visual disturbance noted and is more prominent with posterior subcapsular cataract and anterior cortical changes.

Contrast sensitivity: Though significant loss may be noticed without a similar loss in Snellan visual acuity chart, it is not a specific indicator of vision loss due to cataract.

- **Myopic shift:**With the progression of cataract, the dioptric power of lens increase and cause myopic shift of mild to moderate degrees. This diminishes the need of spectacles for hypermetropic or emmetropic patients and is called "Second sight". This is observed with nuclear sclerosis and disappears with further deterioration of vision. Anisometropia may be produced due to unilateral lens -induced myopia. Also scarcely, hyperopic or astigmatic refractive errors may be associated with cataractous lens changes.

- **Monocular Diplopia or Polyopia:** At times the changes in the lenticular nucleus will be restricted to the inner layers of the lens nucleus and results in multiple refractile areas. This will be best appreciated as irregularities in the uniformity of the red reflex .This will result in in monocular diplopia or polyopia

- **Coloured halos:**In Intumescent cataract, lens will be swollen due to hydration.So the water droplets will cause breaking of white light into coloured spectrum as it passes through and this results in coloured halos.

Signs:

- **Visual acuity**: based on the location and maturation of cataract visual acuity can range from 6/9 to mere perception of light.

- **Colour of lens:**

  Nuclear cataract-grey/amber/brown/black

  Immature senile cataract-greyish white

  Senile mature cataract -Pearly white

  Hypermature → Morgagnian: Milky white with brown sinking nucleus

  → Sclerotic: Dirty white with hyperwhite spots

- **Iris shadow:**In presence of a clear cortex between opacity and pupillary margin, a crescentic shadow of the pupillary margin is formed on the greyish opacity of lens when a light is shown obliquely. It is a sign of immature senile cataract.

- **Distant direct Ophthalmoscopy:** A cataractous lens shows a black shadow against a red glow in the area of opacity. Complete maturation results in no glow.

- **Slit lamp biomicroscopy:**The examination on a fully dilated pupil is done and the complete morphology of the lenticular opacity noted(site, size, colour pattern ,hardness)

Clinical features Of Hard Cataract:

The main symptom, and in most cases the only symptom, associated with hard cataract (Grade III-IV nuclear sclerosis) is decreased visual acuity. All the other symptoms associated with immature cataract are generally absent.

Examination would reveal a visual acuity worse than 6/60 to mere perception of light.Slit lamp biomicroscopy will show a brown or black nucleus, without an iris shadow. The lens capsule should be evaluated for capsular folds and calcificspots. The zonular apparatus should be examined for noting down any zonular weakness associated mainly with hypermature cataract. A fundal glow will either be very faint or may be even absent in such cases.

MANAGEMENT OF CATARACT:

The research for an effective medical therapy for cataract has been ongoing for years. Based on the current available hypothesis of the mechanism of cataract formation, various drugs have been evaluated for their potential anti-cataract effect, but none has scientifically proven to be effective.

One technique used to provide better visual status to the patients who had posterior subcapsular cataract in the earlier days were to prescribe mydriatic drops to the patient. Mydriasis would increase the amount of light entering the eye in case of a central opacity and result in better visualization. Also, the cases of immature cataract and nuclear sclerosis were tried to treat with refraction. As the patients used to get some amount of improvement, it led to the delay in them presenting for surgery and most of these cataracts went on to become mature or hyper mature.

As of now, the management of a patient of cataract is the surgical removal of the cataractous lens with implantation of an intraocular lens. This has been subjected to drastic and throughgoing changes. Ophthalmic surgeons have witnessed a significant evolution in surgical techniques for cataract extraction in the 20^{th} century.

EVOLUTION OF CATARACT SURGERY :

Cataract surgery may be considered among the most successful treatments in all of medicine. It is the only standard method of treatment once the cataract becomes visually significant.

The definition of "visually significant" has altered along the trimline and is currently defined as visual acuity of 20/40 or worse. During the emergence of cataract surgery, a "visually significant" cataract was "likely used to describe an advanced or mature cataract and now with advancements in surgical techniques and enhancement of safety profiles, the indications and threshold for cataract surgery clearly have shifted to cataract removal at a much earlier stage of development."

Evolution of techniques for cataract surgery: timeline

Technique	*Year*	*Author/ Surgeon*
Couching	800	Susutra
ECCE* (Inferior incision)	1745	Daviel
ECCE (superior incision)	1860	von Graefe
ICCE** (tumbling)	1880	Smith
ECCE with PC-IOL***	1949	Harold Ridley
ECCE with AC-IOL****	1951	Strampelli
Phacoemulsification	1967	Charles Kelman
Folbable IOLs	1984	Mazzocco
Capsular Surgery	1992	D J Apple
Accommodating IOLs	1997	Cummings/Kamman
Phakonit/Microphaco/	1998	A Agrwal/RJ Olson
Dye-enhanced Cataract	2000	SK Pandey/L Werner/Surgery DJ Apple

Couching : Couching is the ancient method described to treat cataract which dates back to 600 BC**.**(4)The word "couching" has its origin from the French verb "coucher," which means "to put to bed". Here, instead of eliminating the cataract from the eye, it is displaced from the visual axis. So, the cataract will still persist inside the eye but no longer a hindrance to the passage of light and results in abrupt improvement in the vision. Initially it was considered a successful procedure but the retained cataractous lens and the lack of aseptic technique soon had deleterious effects on the eye and studies have shown that it was associated with complications like corneal opacities, retinal detachment, optic atrophy, secondary glaucoma, phthisis bulbi and painful blind eye. It was seen that eighty percent of the subjects who underwent couching had complained of either poor vision, blurring of vision, or the inability to see clearly. Unfortunately, couching is still in practice in some developing countries.(5)

Intracapsular Cataract Extraction: In 1753, Samuel Sharp performed the first documented intracapsular cataract extraction (ICCE)(6) **.**The procedure consists of removal of the entire lens along with the lens capsule through a large limbal incision. The zonular fibres were cleaved either using forceps and manually disrupting the zonules , by enzymatic dissolution or cryoextraction. In 1957 Joaquin Barraquer was the first surgeon to utilize the enzyme alpha-chymotrypsin to dissolve the lens zonules(10). The advent of modern anaesthetic and sterilization techniques lead to the triumph of ICCE ,however the acceptance declined with the improvisations in the field of ECCE.Larger incision along with slow healing and high surgical astigmatism ,

endothelial decompensation and cystoid macular edema were some of the major complications.(7)

Extracapsular Cataract Extraction: With expansion of the knowledge about the anatomy and diseases of the eye ,the outlook to cataract surgery underwent changes.The procedure of Extracapsular cataract extraction which dates back to as early as 600 BC when an Indian surgeon, Sushhruta(44) may have been the first one to perform it. It is termed extracapsular as the capsule if left in place. The first true procedure done in 1747 by Dr.Jacues Davis consisted of creating a large corneal incision, nuclear expression and curetting the lens cortex(45). Although this procedure represented great progresscompared to couching, postoperative complications were considerable, including poor wound healing, retained lens remnants, posterior capsular opacification and infection. However,it later remerged in 1970s following improvements in operative methods and surgical tools. Overtime the techniques have improved and overall success rate is now 90-95%(46).

Modern Cataract Extraction and Phacoemulsification

One major event when led to the refinement of refractive outcome after surgeries was the emergence of an IOL to replace a cataractous lens. The advent of viscosurgical devices in 1872 upgraded the surgery in terms of facility and safety.

In 1967, revolution came in the field of cataract surgery when, an American ophthalmologist, Charles Kelman introduced phacoemulsification as a surrogate procedure to ECCE. In phacoemulsification, lens was aspirated through a smaller(3-4mm) incision by using an ultrasound-driven needle to emulsify the lens.

Though initially met with hostility, it is now regarded as the safest and preferred method in the modern era. It furnishes shorter recovery time, less surgically induced astigmatism and a more stable AC during surgery. It still continues to get refined and the amount of precision is commendable. So ever since the emergence of phacoemulsification in 1960s, it has replaced the older techniques to be the principal choice of most of the ophthalmic surgeons for an elective surgery.

The integral part of this procedure is a well-functioning phaco machine with all its attachments. A clear knowledge about the same is crucial when we have to perform phacoemulsification under various circumstances and complications.

PHACO MACHINE AND FUNDAMENTALS:

The phaco machine can be considered as a composite segment of technology that control the fundamentals of fluidics, that is, the inflow and outflow of fluid from the anterior chamber and dispense ultrasonic energy to the tip.

Phaco Console:It is the computer which manages all the phaco parameters.The power,vacuum and flow rate settings are fed into the console.These basics are managed by various adjustable factors which are controlled intraoperatively with the help of foot pedal.

• In the standard phaco foot pedal, the vertical distance travelled is divided into three zones:

• Step 1: Operates the irrigation mode: all /none step

• Step 2: Operates the aspiration system

• Step 3: Operates phacoemulsification

Figure 1: Phaco machine

• **Linear control** refers to the reaction of the foot pedal in a fashion proportional to the amount of foot pedal depression. This enables the fine tuning of the machine intraoperatively. In previous models, this control was not installed and hence the machine functioned on an all-or-none basis.

Additional mechanisms in to control reflux of fluid and facility to change to different modes are installed in the foot switch

There are two basic kinds of phaco machines, the peristaltic and the venturi, varying in the fashion in which they cause fluid outflow.

Phacodynamics and fluidics:

Fluidics: The flow of balanced salt solution inside the eye and how closed chamber dynamics are active during phacoemulsification constitutes fluidics.

Phacodynamics: It is the interactivity between the ultrasonic power and fluidics

Power/Cumulative Dissipated energy:

• Power in a phaco machine is the end product of vibrating piezo-electric crystals(around two to six crystals will be present in the hand piece). Each crystal will vibrate at a frequency of 28,000 Hz to 60,000 Hz, which is the domain of the ultrasonic.

• This vibration issues a back and forth motion to the phaco tip, which in turn is converted into cutting power. The excursion of the phaco tip is termed its stroke length. This value of stroke length is in between 0.05 to 0.15 mm.

• The stroke length is a varying entity whereas the frequency for a particular machine is pre-determined. It is the variations in stroke length that give necessary changes in the power generated.

Various mechanisms that describe the cutting action are as follows:

– First mechanism is that the physical movement of the tip that hits the nuclear fragment and disintegrates part of it (jack hammer effect).

– Second mechanism is the generation of an implosion, due to the vacuum created by the sudden backward motion of the tip.

– A third postulated mechanism is the production of acoustic waves in the fluid medium surrounding the tip.

– Linear movement: The movement of the tip is only in the axis of hand piece and provides cutting action in a single axis

-Torsional shearing action of an angulated tip is seen in machines that specifically offer torsional phaco, i.e. the tip has both longitudinal and rotatory movement. This strategy improves the efficiency of the process.

There are various phaco tips available which vary from zero to sixty degrees in angle. With the increase in the angle the cutting ability increases, however the grip tends to decrease

Power Delivery

The generation and delivery of power is modulated with the help of foot pedal. Only in the position three, power is produced which may be under linear control or panel control. The power can be distributed in continuous or pulsed mode

In pulsed mode, the power delivery is again fragmented so as to create micro pulses and the frequency is pre-determined. The delivery of these micropulses is directly proportional to the proportion of foot pedal depression

This pulsed mode provides the upper edge of decreasing the chatter of fragments of nucleus at the phaco tip and increasing the followability. Chatter is described as the tendency of vibrating phaco tip to push aside the materials that comes to it vicinity. Other adaptations that are available include burst mode, where spurts of full power are delivered , which is again controlled by the proportion of foot pedal depression. These additional modes are aimed at lowering the amount of energy dissipated to the eye, improve the grip and followability and decrease the risk of corneal burns.

Irrigation System

• Gravity is the primary determinant of the hydrostatic pressure that drives the irrigation system.

• The pressure involved is proportional to the height of the irrigation bottle above the patient's eye level. At resting state, a higher bottle height means more pressure in the closed system, which equates to a greater IOP and a deeper anterior chamber.

• As the aspiration system removes fluid from the closed system, an equal amount of fluid is replaced through the irrigation system. The higher the bottle, the more readily this fluid is available. However, too high a bottle will cause undue pressure to be exerted and result in zonular stress and patient discomfort.

• On an average, a height of about three feet above the eye level is sufficient.

• Increased availability of fluid to the anterior chamber can be useful in preventing post-occlusion surge. This may be achieved by using a positive pressure pump, which essentially works in the same way as the raised bottle.

• Alternatively, additional flow can be generated by using a TURP (trans-urethral resection of prostate) set or an anterior chamber maintainer. The latter involves creation of an additional corneal incision and provision of a separate infusion line.

Aspiration System

Aspiration system aid in removal of emulsified nucleus and cortical matter from the anterior chamber. Also, the vibrating phaco tip generates heat which is taken

out by the aspiration system. It also aids in generation of holding power for the surgeon.

There are two basic mechanisms involved are:

a. The ***peristaltic pump*** functions by pinching away pockets of fluid in a particular direction, which is carried out with the help of rollers. Usually only a minimal amount of vacuum is created owing to the removal of small pockets of fluid. However, a large vacuum can be built up slowly by stopping further ingression of fluid, for example by occlusion of the aspiration tip. The velocity of movement of the rollers decide the time duration of the vacuum built up .In technical terms, the higher the flow rate (liquid removed per unit time), the shorter the rise time (time required to reach the maximum pre-set vacuum). Also, attention to be given to the fact that the peristaltic system essentially pushes fluid one way, so there is practically no vacuum unless the aspiration orifice is occluded.

b. The ***venturi system*** makes use of the Bernoulli's principle for generation of vacuum, which is then directly transmitted via the aspiration tubing. As opposed to a peristaltic pump, here fluid removal is preceded by vacuum generation. Thus, occlusion of the phaco tip is not a prerequisite to generate vacuum, a fact which gives a better 'pull' in a venturi system.

• Compliance: According to the laws of physics, vacuum is distributed uniformly inside the lumen of the aspiration tubing and compliance is defined as the tendency for the collapse minimally with generation of vacuum .

• As occlusion breaks, there is an inflow of fluid and, at the same time, the tubing also springs back to its original volume.

• Thus, fluid is suddenly taken up by the aspiration system, which may cause a temporary shallowing of the anterior chamber. This is called ***post-occlusion surge***, and it can be very dangerous. It is interesting to note that there is a fundamental difference in how the peristaltic and venturi systems experience surge.

In a peristaltic system, loss of occlusion causes vacuum to drop to zero, permitting the aspiration tubing to regain its full, pre-occlusion volume. This draws in a greater amount of fluid and the surge experienced is bigger.

In a venturi system, some vacuum remains in the tubing even after the break of occlusion. The increase in volume of the aspiration system is not as large as in a peristaltic system, and thus the consequent surge is also lesser.

Higher end machines incorporate a variety of systems to detect occlusion and use technological solutions to prevent surge. These include customizable post occlusion settings that effectively stop or slow down proceedings as occlusion is achieved, resulting in an exceptionally safe surgical environment.

Followability

Removal of fluid from the anterior chamber sets up unidirectional currents in the eye, simulating a source-sink system. This results in the flow of any loose material towards the aspiration port, creating an attracting force called followability.

As the flow rate increases, so does the followability. So, in practical situations if the surgeon wants to draw any loose material towards the tip, he needs to set the flow rate to a higher setting.

Vacuum

Once the aspiration port is occluded, vacuum starts to rise. With the occlusion of the aspiration port the vacuum begins to rise. The surgeon predetermines the upper limit of the achievable vacuum and the system will extract fluid until this mark is reached. Vacuum in the system provides a hold over whatever occludes the port. So, in surgery if u need to grip the fragments of nuclei, just need to employ a higher vacuum.

The basics steps followed in a phacoemulsification is similar to that of the ECCE in the initial steps but several modifications exist.

Basic Technique Of Phacoemulsification:

Incision:

The incision should be planned in such a way that along with giving access to the cataractous lens, it shouldn't allow fluid leakage, induce minimum astigmatism and should be self-healing.

Superior incision has the advantage of fewer incidences of post-operative endophthalmitis but is having greater induced astigmatism as compared to the temporal incision. The incision has to be bevelled and ideal configuration is an incision in square form whish is as wide as it is long.However in practice, a tunnel which is 2.8 mm wide, with 1,5 mm into the cornea is quite stable.

For proper action of then valve, inner lip must be at a uniform distance from limbus. Compared to a uniplanar, and biplanar incision,triplanar enhances the valvular action

Side port incision: they are required for introduction of instruments like chopper,rehxis needle etc. They are made bevelled and pointing towards centre of nucleus. They are usually placed 80 degrees away from main incision.

Capsulorrhexis

The continuous curvilinear capsulorrhexis is preferred owing to the multiple advantage over the can opener and envelope techniques

- Margin in continuum provides a strong edge that resists backward extension
- Well made CCC with adequate overlap with optic edge, promotes shrink-wrap formation and retards posterior capsular opacification
- Handy in tackling nuclear fragments and assist in- the- bag- phaco, which is less traumatic for corneal endothelium
- Absence of capsular tags facilitates cortical clean up
- A good CCC is about 5 -5.5 mm in diameter

Hydro procedures

Hydrodissection: Cleavage between capsule and subcapsular cortical fibers. Hydro delineation: Separates the harder endonucleus from the soft epinucleus Care to be taken to prevent fluid entrapment inside capsular bag which can be seen as lifting up of central nucleus along with marked shallowing of anterior chamber. Further injection of fluid can result in posterior capsular tear.

Nucleus management techniques:

The crux of the surgery is this step and it requires expertise for fragmentation of nucleus into manageable pieces and taking them out through the small lumen of phaco tip. It is nothing short of an art when u achieve this meticulously. There are many techniques and approaches for the management of the same.

The first one to describe the nucleofractis technique was Gimbel(12). He named it the divide and conquer nulceofractis. From that time, many variations in the division of nucleus was discussed, like the phaco chop and stop and chop. Several modifications like horizontal and vertical chop have come up(13–15). Each have a very unique and distinct advantage and popular with the surgeons. The most popular techniques of nuclear management are discussed here:

Four Quadrant, or the Divide and Conquer

• In the divide and conquer technique, two deep grooves or trenches are made in the nucleus, Injection of a wave of fluid through the immature cataract results in hydro dissection (A) Fluid aimed to separate the harder endonucleus from the softer epinucleus, is termed hydro delineation (B). Note the golden ring marking the reflecting interface of the separated endonucleus, which would be emulsified 80 to 90 percent depth. This is called trenching or sculpting

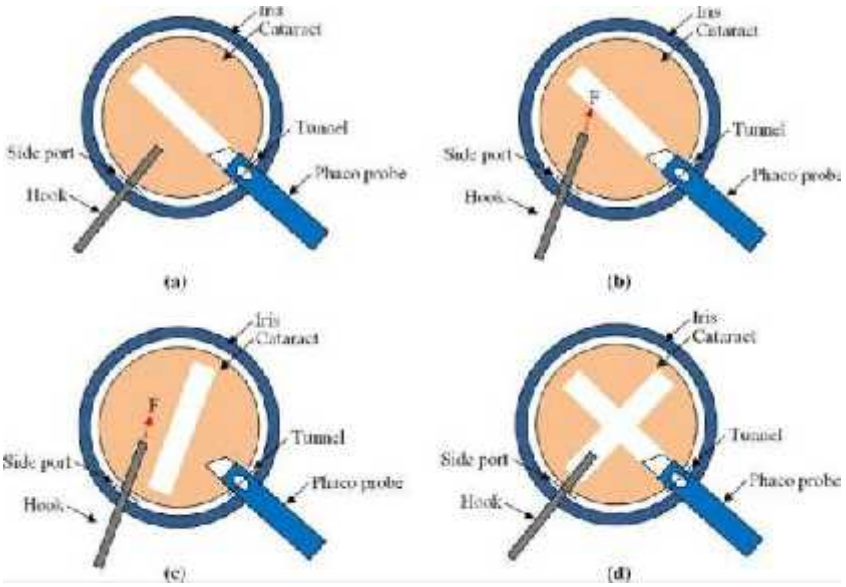
• These are at right angles to each other, making a cross sign as viewed from the microscope

• The nucleus is then divided into four segments along these grooves, and each segment is then emulsified independently

• This is a particularly efficient technique for hard cataracts and for the beginning surgeon.

• The downside is increased phaco energy dissipated in the eye during sculpting.

DIVIDE AND CONQUER



Stop and Chop

• In a stop and chop technique, single deep trench is made and the nucleus bisected along it

• The two hemi-nuclei are progressively chopped into smaller fragments and emulsified.

• Lesser phaco energy is used and more emphasis is placed on using fluidics to remove the cataract and hence less damage to the corneal endothelium.

STOP-AND-CHOP-

Direct Chop

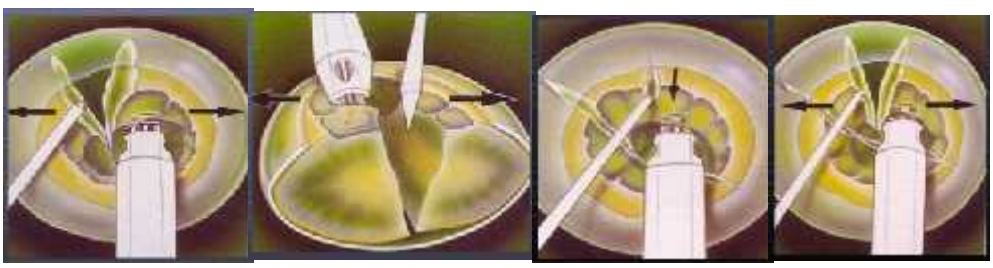
• In the direct chop technique, no trench is made; the probe is buried in the centre of the nucleus and fragments are generated by chopping

• Phaco energy required is the least when compared to other techniques.

A good understanding of phacodynamics and proficiency in chopping are prerequisites to nucleotomy by direct chop.

• It is important to remember that the nucleus is also a resource that needs to be used properly during surgery. Repeated attempts at burying without establishing a proper grip will lead to loss of this resource, and the surgeon may be left stranded with a doughnut shaped nucleus-epinucleus complex, which can be difficult to manage.

DIRECT CHOP



Retro chop technique (61)

It consisted of creation of an oval capsulorrhexis. The advantages being, it provides a larger axis which will avoid excessive tension to the zonular apparatus and small axis ensures overlapping the optic edge and maintaining the centration as well as the stability of IOL.Also, the broader axis helps in tilted the nucleus as facilitating retro chop at a later stage.

After judicious hydro dissection, nucleus is rotated and the phaco tip and the retro chopper inserted. Once we get hold of nucleus, it is tilted to expose part of the posterior face, making space for the retro chopper. This is achieved by a slight rotation of the phacoemulsification handpiece. The design of the chopper allows the upper cutting edge to be moved toward the phaco tip.

Proper execution of this manoeuvre, fabricate a fracture that starts at the posterior portion of the nucleus and pierces through the nucleus toward the anterior portion. This motion is repeated after rotation of lens and after the lens is rotated, similarly the nucleus is disassembled into smaller fragments. Phacoemulsification of these fragments is then performed, keeping the bevel down.

Decrease and conquer(62)

This technique consists of first creation of a crack in the superficial epinuclear plate and pealing it down from the denser endonucleus. First the isolated endonucleus is fragmented and emulsified followed by the remaining epinulcear plate.

Tilt and crack:

In this technique the lens is transfixed with the help pf phaco tip and the other pole of lens id tilted out of then capsular bag. This will give chopper better access to the posterior plate and effective chopping can be performed.However,there is question

on the amount of stress exerted on the zonular fibres. This can be reduced by a larger or oval capuslorrhexis.(61,63,64)

Drill and chop

There are several modifications of this technique. It consists of piercing the phaco tip deep into the nuclear material sand creating a small bore hole into the deeper layers. If the tip reaches the deep levels of the nucleus, even the challenging cases can be tackled easily, but it's often difficult to assess the percent of penetrating within the narrow hole(65)**.**

Epinucleus removal

It is the soft shell surrounding the harder endonculeus.As a rule, phaco energy is not required for its removal short bursts may be needed to clear the lumen of the probe. Initially anterior plate cleared, followed by equatorial and at the end the posterior plate which is flipped and cleared.

Cortex removal

- Unimanual or bimanual automated irrigation aspiration is used.
- The parameters on the phaco machine has to be changes from the phaco mode to the irrigation-aspiration mode.
- Aspiration tip is smaller than phaco tip, higher flow settings can be used.

- Aspiration tip positioned below the rhexis margin and in the middle of cortical fibre. Once cortex grasped, then it should be pulled to the centre to aid peeling it off from the equator. Side to side movement as aspiration progresses to prevent accidental capture of capsular rim. If any sticky residual fibers present, low vacuum mode called capsular vacuum mode can be employed**.**

Implantation of IOL

- Rigid IOL-here the initial incision will have to be enlarged to accommodate the optic diameter of the rigid IOL.

- Foldable IOLs can be delivered by injection based or forceps-based systems.

- Injection based-IOL may be preloaded or some with an injection assembly. It ensures delivery straight into the bag without the risk of picking up contaminants on the way

- Forceps based-forceps used to fold and implant the IOL

Wound closure

Wound is self-healing by design and do not require any closure.

Hydration of the corneal stromal is a common practice. Sutures can be put if there is any question about the integrity of the wound construction.

Though the procedure is short, it is not one without complications .Risks lie at every level and can affect the final outcome of the procedure and even sight threatening complications can ensue along the course.

Complications of Cataract Surgery:

The cataract surgery is not one devoid of complications. Even at the experienced hands there can be various complications that can arise and the real capability is in the management of such emergency situations.

The complications are discussed as follows:

Anaesthesia:

• Globe perforation (52)

• Retrobulbar haemorrhage.

• Accidental IV injections leading to drug related complications

• Bradycardia following Oculocardiac reflex.

• CNS toxicity→unintended injection into the optic nerve (53)

• Injection of the wrong drug may lead to necrosis and loss of eye and surrounding tissue.

• Facial nerve or tympano-mandibular joint injury

• General anaesthesia Complications

• Worsening of subluxation of lens

• Hypersensitivity reaction to lignocaine/hyaluronidase -rare(54)

PREOPERATIVE PREPARATION

• Corneal abrasion

• Lid abrasions or minor cuts during preparation of lashes

• Wrong eye

Preincision steps

• Damage to the lids

• Perforation of the globe while passing the superior rectus bridle suture.

• Conjunctival buttonholing

Incision

- In ECCE-a superficial wound with jagged edges will make the suturing difficult and lead to wound leak post-operatively
- If any superficial cut occurs in the tunnelled incisions, as in SICS and Phaco, it can create issues with the wound closure
- A short entry can affect the generation of a self-sealing valve(55)
- The accuracy of the incision dimensions is significant especially for creating tunnels and can result in corneal folds and short tunnels lead to wound leak.
- Wound burn due the hindrance to fluid flow through sleeve around phase tip in case of a tight tunnel(56). Also, it may cause the tip to be more compressed against corneal tissue permitting more heat transfer. The usage of microflow tips with grooves can reduce this problem to some level.
- Loose tunnel enables fluid leak and causes instability of anterior chamber

- The incorrect technique of keratome entry can create tears in anterior capsule and make affect the smooth progression of rhexis. Both the main incision and the side-ports are susceptible.It also has the additional risk of damage to the central cornea
- Care to be taken during wound extension to avoid irregular extension, damage to the iris/anterior capsule etc.
    - Poor construction of side port may result in wound leak.

Capsulotomy And Hydroprocedures

• Posterior extension of the capsular tear-improper joining of radial cuts in can-opener technique

• Extension of the tear to the periphery in continuous curvilinear capsulorrhexis (CCC) →intumescent cataract, inexperienced surgeon, shallow chamber, larger rhexis(>6mm)

• Creation of a small rhexis (< 4 mm): Risk of fluid entrapment while performing hydro dissection, and consequent rupture of the posterior capsule with resultant loss of capsular contents into the vitreous humour.

• The smaller capsulorrhexis can cause difficulty in instrumentation while doing phacoemulsification.

- If the size of the rhexis is larger than the optic size, then there won't be "shrink-wrap" effect and chances of posterior capsular opacification post operatively is higher.(57)

• Posterior extension of a torn rhexis or one with a 'V' shaped weak area mayoccur in response to the hydro dissection wave. This happens as the fluid increases the intra-

capsular bag pressure, which then pushes the nucleus forwards, causingthe weak area of the capsular rim to give away.

Nucleus Management

• Nucleus rotation ensuing the hydro procedures can give rise to zonular dialysis, mainly in presence of capsule-cortical adhesions. This can be avoided by creation of a larger rhexis, adequate hydro procedures, gentle circumferential movements, and bimanual rotation.

• Damage to structures like cornea or iris.

• The presence of hard, leathery bridging fibres which keep the nuclear fibres together can make phacoemulsification difficult.

- The phacoemulsification of soft cataract has the risk of nuclear bits breaking away from the main body and resulting in a ring of nucleus/cortex which is more difficult to be removed from the equatorial region. Early adequate hydro dissection with low phaco parameters(except flow rate) are required to counter this

• Conjunctival ballooning: Tackled by nicking the conjunctiva close to the limbus, just about the main incision.

• Damage to corneal endothelium-Damage can be due to phacoemulsificationenergy, the turbulent fluid flow, floating anterior chamber debris, and during instrumentation.

- Stromal hydration-can affect the post-operative visual acuity (58)

• Posterior capsular tear -dealt by providing viscoelastic tamponade and lowering of the bottle height

• Nucleus drop -calls for intervention by a trained vitreo-retinal surgeon

• Vitreous loss -Associated with postoperative complications, including retinal detachment, secondary glaucoma, CME, IOL decentration and bullous keratopathy.

Cortex Management

• Risk of pull on anterior or posterior capsule leading to posterior capsular rupture or zonular detachment (anterior)-mainly with simcoe cannula. The anterior capsular tags are more at risk.

IOL Placement

- Damage to ocular structures
- Worsening of pre -existing subluxation due to the uneven pressure to the weak zonular apparatus during IOL placement
- Upside down placement of the IOL, especially seen with square edged IOL or ones with angulated haptics
- Perforation of capsular bag at the equator during IOL (three piece or C/J loop haptics) manipulation. This results in the lens being off axis and irregular astigmatism post operatively
- Complications like secondary glaucoma, bullous keratopathy, post-operative uveitis decentration are commonly associated with Scleral fixated or anterior chamber IOLs

Other Intraoperative Complications

• Subconjunctival haemorrhage.

• Corneal abrasion due to inadvertent trauma.

• Descemet's membrane detachment(59)

• Possible posterior segment lesions which gets revealed

• Expulsive haemorrhage -common with coexistent glaucoma, previous filtering surgery and hypertensive patients

Postoperative Complications

• Shallow anterior chamber-to be assessed to find the cause

• Endophthalmitis-mostly bacterial

• Toxic Anterior Segment Syndrome (TASS): It may present as early as 24 hours postoperatively. The basic aetiology is inflammatory response to any toxic material that the eye hasbeen exposed to, during surgery. It can be toxins in viscoelastic, irrigating fluids or residues on improperly sanitized instruments.

• Iris prolapse: Early detection- Iris reposited back into the anterior chamber

: Late detection- Removal of iris tissue with resuturing of the wound

• Corneal edema: Indicator of injury to corneal endothelium

• Retained lens matter resulting in increased postoperative inflammation and secondary glaucoma

• Postoperative refractive error:

- High spherical error: Miscalculation of the IOL power, implantation of the incorrect IOL, or because of inherent formulae deficiencies in patients with unusually long or short eyes.
- High cylindrical refractive error: IOL tilt, or excessively tight suturing.

• Ptosis postoperatively-injury to superior rectus(60)

• Postoperative uveitis.

• Secondary Glaucoma.

• Retinal detachment.

• Choroidal haemorrhage.

• Cystoid macular edema.

• Bullous keratopathy.

• Posterior capsular opacification.

• IOL position shift-sunset syndrome.

• Hyphaema.

• Epithelial downgrowth or fibrous ingrowth.

Appropriate pre-operative assessment, and careful intraoperative manoeuvring goes a long way in their prevention.

As the cataract surgery revolutionized through the years, it underwent transformations. The objective of providing visual improvement give way to a much broader outlook.

In the developed world, cataract surgery has transformed into more of a refractive procedure with aim of achieving independence from spectacles.

Laser cataract surgery:

Femtolaser technology was applied to LASIK refractive surgery for creation of the corneal flap, resulting in a more precise LASIK flap in 2001. In 2008 at Budapest, Hungary (47),this technology was employed for the first time in performing the first femtosecond laser-assisted cataract surgery.

Rather than obviating the need for phacoemulsification, the laser performed many of the steps of the cataract procedure, including construction of the main

wound, capsulorrhexis, and fragmentation of the lens. Limbal relaxing incisions to correct astigmatism are often accomplished with the aid of laser. Additional benefits would be reducing the risk of infection, reducing endothelial cell loss and improving the refractive outcomes.

With femtosecond laser technology, visual acuity outcomes are thought to be more precise, predictable, and reproducible compared to conventional cataract extraction. However, till date no data supported that femtosecond laser–assisted cataract surgery furnished better outcomes than manual phacoemulsification surgery. As yet both the approaches yielded similar results in terms of safety and efficacy.(48)

Intraocular Lenses

The incredible success of cataract surgery would not have been possible without the development of intraocular lenses (IOL). The first IOL was implanted in 1949 by Sir Harold Ridley, a British ophthalmologist. Prior to the introduction of IOLs, patients were aphakic after cataract surgery and managed with high -powered hyperopic spectacles post operatively. Sir Harold Ridley observed that wounded World War II pilots tolerated plastic pieces of shattered airplane windshields in their anterior chambers(49), and this formed the ground discovery behind implantation of an IOL made of polymethyl methacrylate (PMMA), also called acrylic glass.

Since Ridley's innovative discovery many exceptional developments in IOL technology and design have occurred. IOLs can be implanted in various sites, including in the anterior chamber, tied to the iris, in the ciliary sulcus or in the capsular bag. When IOL implantation was introduced, ICCE was the predominant

method of cataract extraction. Early lens designs were not compatible with long-term safety in the eye.

When ICCE lost its popularity, IOLs were then designed with the intent of posterior chamber implantation. An American ophthalmologist, Steven Shearing, is credited with bringing IOL design into the modern era. In the 1970s he designed a lens that could centre itself in the same position where the natural lens was positioned (behind the iris).

As advances continued in cataract surgical techniques, a more structurally sound place for the IOL to reside was created: the capsular bag.

In 1980 the first foldable lens arrived on the scene, which further improved outcomes. Foldable IOLs are made of flexible material (acrylic or silicone), allowing insertion into the eye through an even smaller incision. Since the 1970s, remarkable advances have occurred in IOL technology, design, and material.

In 1992, astigmatism correction became possible when the first toric IOL was developed.(50)Since then, improvements in the toric IOL model have led to excellent results and increased freedom from spectacle correction.

The challenge of correcting presbyopia was taken on with the introduction of multifocal IOLs in the 1990s and of accommodating IOLs in 2000.During the past 20 years, the developments in IOL calculation methods and measuring devices have been astonishing and have resulted in more precise postoperative refractive outcomes.

In 2006, a United Kingdom study to establish benchmark standards for refractive outcomes after cataract surgery suggested that over 50% of patients with normal eyes should be within 0.5D (dioptre) of the desired target refraction and 85%

should be within 1.0D of the desired target refraction. (51)Studies show that in over 90% of cataract surgery, refractive outcomes can be within 1.0D of predicted outcomes and in over 70% can be within 0.5D of predicted outcome when a surgeon tailors his/her lens calculation using prior outcome data. Even with all of the remarkable technology and mathematical formulas, lens calculations are not perfect. Residual postoperative refractive error can be common. Typically, such refractive error is not significant and is tolerated, and can be corrected with glasses or contact lenses if needed.

There are many adjustable IOL technologies under development, including light adjustable IOLs, multicomponent IOLs, mechanically adjustable IOLs, and magnetically adjustable IOLs.This technology will lead to a higher level of precision in cataract surgery in the future.

As the hardness of nucleus increase with maturation the procedure of phacoemulsification becomes more difficult.

Hard cataracts are all those nuclei which are dense ,firm and can withhold pressure. It cannot be easily cracked, crushed and penetrated like a rock solid. The epinuclear plate, the protective layer is usually deficient here and along with the sparsity of the surrounding cortex, weakness of the zonular apparatus, laxity of the capsule amplifies the risk of injury to the surrounding structures during surgery. So, when you have to deal with a dense cataract, it is quite challenging and is associated with many problems that can arise due to the use of ultrasound energy mainly, damage to the corneal endothelium.

Phacoemulsification In Hard Cataract:

The successful management of a cataract surgery by phacoemulsification depends on various factors and a pivotal element is the firmness or brunescence of the lens. Even experienced surgeons view phacoemulsification in hard cataracts as challenge.

The factors to be taken care of are:

• Poor fundal glow resulting in reduced visibility

• Changes in the capsule, making it fragile.

• Large nucleus size reducing manoeuvrability within the capsular bag.

• Capsulo-cortical adhesions making nucleus rotation difficult.

• Scarce epinucleus which makes hydro delineation almost impossible.

Advantages:

- Topical anesthesia may be sufficient for phacoemulsification, esp. in expert hands
- Small incision is one main advantage and it is self-healing by design and will not require any suture.
- The smaller incision will result in a more stable Anterior Chamber with a better control during capsulorrhexis or hydrodissection.

- Post-operatively, less risk for leakage and reduced risk of endophthalmitis.
- Also, a smaller incision will result in early visual rehabilitation and better unaided visual acuity due to rapid post-surgical recovery and minimal surgery related complications

- Post-operative surgical astigmatism which was found to be higher with the earlier techniques,like ICCE,ECCE was less for phacoemulsification.
- Phacoemulsification when done in posterior chamber without prolapsing the nucleus into AC will minimize the risk of corneal complications.

Disadvantages

- Learning curve is more and for the surgeon to become experienced to tackle various complications will take more time duration.
- In Phacoemulsification,the duration of surgery and phaco power used all vary depending up on the density of nucleus, whereas in SICS the time spent per patient doesn't vary much .Also difficult to deal with hard cataracts and corneal endothelial decompensation can be the result.
- Expensive devices and instruments might be a deterrent in especially the developing countries
- The procedure is machine dependent and in the event of machine failure, one will have to shift to conventional ECCE.
- The more ultrasound energy used can have a detrimental effect on the corneal endothelium.

Despite all these challenges, we can achieve favourable outcomes congruously by a through preoperative assessment of the cataract, cautious designing and implementation of the steps and being well prepared antecedent for any complications. In expert hands,the complication rate is minimal and the technique provides an almost quiet eye early post-operatively with early visual rehabilitation.

SURGICAL TECHNIQUE: GENERAL CONSIDERATIONS

Anaesthesia:

Determining the ideal anaesthesia for a more complicated cataract can influence the result .Either topical or peribulbar anaesthesia can be used to perform the surgery and the decision is mostly dependent on the surgeon's comfort level. If any extensive manipulation of irs,longer surgical time is anticipated peribulbar anaesthesia is preferred to increase patient cooperation.

Incision:

Phacoemulsification is associated with high possibility of loss of capsular support, one may consider a near clear or a scleral tunnel that can accommodate a sutured Posterior chamber or anterior chamber IOL.Along with a 6-7.0mm external wound, internal wound should be large enough to fit in phaco tip. This is important for maintaining a tight anterior chamber and thereby preventing excessive wound leak.

Capsulorrhexis

It is crucial to have a continuous and adequately sized capsulorrhexis for a successful phacoemulsification. The visibility can be affected due to the lack of poor fundal glow. To add on to the difficulty, capsule can be fragile and can tear off with ease. To help in capsulorrhexis, either trypan blue dye can used to stain it or an endoilluminaor can be used. The use of a rhexis forceps help in providing better control. A case of white cataract may be associated with raised intralenticular pressure from the liquifies outer cortex and a hard-central core of nucleus. This can result in the Argentinian blue flag syndrome. To prevent this the anterior chamber depth should be increased with an appropriate viscoelastic and maintenance of a close AC is also important.Also the presence of capsular folds and calcific deposits on the anterior

capsule seen associated with hyper mature cataract make the process of capuslorrhexis challenging.

Hydro dissection and Nucleus Rotation

Dense cataracts have increased possibility of sudden blow out of the posterior capsule during hydro dissection (66)procedure due to a bulky nucleus preventing exit of the injected fluid. This necessitates the need for a gentle hydro dissection for loosening the capsulocortical adhesions and aiding in the nuclear rotation.It can be made easier by multiquadrant hydro dissection.(67).It is not recommended to hydrodelineation. If rotation by a single instrument is met with resistance we can go for bimanual rotation of the nucleus.

Phacoemulsification Procedure

Any strategy described can be used for the nucleotomy, but some points specific for hard cataract should be kept in mind. They are as follows:

- As compared to a soft cataract, in dense cataracts greater proportion will be occupied by nucleus and cannot be isolated by hydrodelineation. So, the techniques which includes the creation of a central space if preferred. These include the trenching techniques, i.e. the four quadrant or the stop and chop.

- Care should be taken to avoid stress on the zonular apparatus while the nuclear sculpting done. This step should be carried out with adequate power so that rather than pushing there is actual cutting of the nuclear material at the phaco tip level. The settings should be low while this is being done. A bent phaco tip such as the Kelman tip is particularly useful in sculpting the depths of the nucleus

- If one is planning phaco-chop, should either go for horizontal or vertical chop or a combination of both. A horizontal chop will require use of a blunt chopper and the vertical chop will require use of a sharp chopper.

- Meticulous separation of bridging fibers linking the individual fragments should be undertaken after cleaving the hard nucleus. Otherwise it can interfere with the chopping by dragging a larger fragment along with the piece that is undergoing emulsification

- During emulsification of nuclear fragments, it should be kept in mind that, the sharp edges of the fragments can cause posterior capsular tear. So, we can go for creation of smaller fragments by repeated chopping. Utmost care to be taken as we aspirate the last nuclear piece because the epinuclear cushion is very thin.

Cortical Aspiration

The completion of cortical aspiration can be quickly performed in view of minimal cortex in hard cataracts. However, the posterior capsule is extremely thin and maximal care should be taken to prevent tearing the capsule.

These are additional points to be kept in mind as you deal with a hard cataract.

Complications of phacoemulsification in hard cataract

- Corneal edema
- Corneal or scleral burns due to prolonged phaco time
- Corneal decompensation due to higher endothelial cell damage
- Stress on zonular bag during sculpturing resulting in zonular dehiscence
- Ultrasound dissipation to other tissues

- Posterior capsular rent due to intense cortical aspiration
- Higher intralenticular pressure resulting in extension of rhexis margin

These are complications which can be tackled with experience and a skilled surgeon can perform the procedure smoothly without usage of much phaco energy or time. This will avoid any deleterious effect on the cornea, mainly its endothelial layer. Once these problems can be managed then the benefit of a small incision with minimal surgically induced astigmatism and early visual rehabilitation definitely outweighs an SICS and is the best technique even for a hard cataract.

METHODOLOGY

The present study was conducted at Department of Ophthalmology, Dr. Prabhakar Kore Hospital and Medical Research Centre, Belagavi on patients who are diagnosed with grade iii- iv nuclear sclerosis and willing for phacoemulsification with IOL implantation.

Source of data: All the patients who are diagnosed with grade iii- iv nuclear sclerosis who is willing for phacoemulsification, attending the OPD of the Department of Ophthalmology, Dr. Prabhakar Kore Hospital and Medical Research Centre meeting the inclusion criteria.

METHOD OF DATA COLLECTION:

STUDY DESIGN:

One-year prospective randomized control trial

STUDY DURATION:

One year: 1st January 2019-31st December 2019.

SAMPLE SIZE:

A sample size of 96 cases randomized into two groups of 48 each

SAMPLING PROCEDURE:

The minimum sample size formula based on mean and standard deviation is

$$n = \frac{(z_\alpha + z_\beta)^2(s_1^2 + s_2^2)}{(\bar{X}_1 - \bar{X}_2)^2}$$

where

z_α is linked with the level of significance

z_β is linked with the power of the test.

For 5% level of the significance z_α =1.96 and z_β =0.84 for 80% power of the test.

$\bar{x}_1$ is the mean of the first group (15.1) and $\bar{x}_2$ is the mean of the second group (18.1).

s_1 is the standard deviation of the first group (3.8) and s_2 is the standard deviation of the second group (5.6).

With these values the minimum sample size obtained is 40.

Note: This is the minimum sample size. If possible one can take cases little more than the number so that the results become more confirmative. There is no condition that there should be equal number cases in the two groups Both should exceed the minimum sample size.

Selection Criteria:

Inclusion criteria

Patients with-

1.Age related cataract planned for phacoemulsification cataract surgery.

2.Patients with nuclear density grade III or IV, graded by colour using slit lamp bio microscopy

1=green,2=yellow,3=amber,4=brown or black

Exclusion criteria

Patients with-

- Corneal disease or opacity
- Inadequate pupillary dilatation
- Glaucoma
- Pseudoexfoliation syndrome

- Uveitis
- Previous ocular trauma
- Previous ocular surgery
- Subluxated Lens

METHODOLOGY PROPER:

All the patients who satisfy the inclusion criteria were included in the study. The patients were enrolled into the study and written informed consent was taken from them by the investigator.

Data regarding demographic parameters such as age, sex, occupation and address were noted on a predesigned proforma by the investigator at the time of first visit.

Detailed history of following symptoms was noted:

- H/O Diminution of vision RE/LE
- Duration
- Gradual/Sudden
- Progression/static
- Distant/Near vision
- Visual improvement with bright light or dim light
- Painful/ Painless
- Diplopia/Polyopia
- Photophobia
- Flashes of light

- Colored halos
- Floaters
- Watering
- Redness
- Discharge
- Black spots in front of the eye
- H/O Curtain falling in front of the eyes
- H/O wearing glasses
- H/O Diabetes Mellitus, Hypertension.

Ocular Examination:

- The best corrected visual acuity will be noted using Snellen's visual acuity chart.
- Ocular examination proper (Adnexa, conjunctiva, cornea, Anterior chamber, iris, and lens).
- Detailed slit lamp bio microscopy to classify and grade the cataract as: -
    - Cortical Cataract
    - Nuclear Sclerosis
    - Posterior Subcapsular Cataract
- Tonometry- IOP will be measured with Non-Contact Tonometer.
- Wet Retinoscopy: with Tropicamide of the other eye
- A thorough posterior segment evaluation will be done using direct and indirect ophthalmoscopy.
- Pre-operative Keratometry
- A scan biometry (SRK II Formula)

- Patency of the lacrimal passages will be checked using lacrimal sac syringing
- Basal parameters such as pulse rate, blood pressure will be assessed.

Routine laboratory investigations included are: -

- ❖ Routine hemogram
- ❖ Diabetic Status

The study included 96 patients who were randomly assigned into either of the two groups that is:

Group A (48): Phacoemulsification with Direct-Chop technique

Group B (48): Phacoemulsification with Stop-and-Chop technique

All the patients underwent phacoemulsification surgery. Single surgeon performed all the surgeries using the standard technique. All the cases were operated under local anesthesia following aseptic precautions.

- A detailed history, written and informed consent will be obtained from all patients after explaining the procedure and associated risk.
- All the investigations were rechecked
- 96 patients were randomly distributed into 2 groups 48 each group. Randomization will be done with the help of random number table.
- One day prior to surgery:

i)Patient will be given antibiotic eye drops: Moxifloxacin+Ketorolac eye drops to be instilled in both eyes once every hourly for four times.

ii) Patient will be started on a course of anibiotics: Tab.Levofloxacin 500mg OD

- On the day of surgery:

  Patients in both groups will be given Itrop plus eye drops (Phenyl ephrine 5% w/v ,Tropicamide 0.8%w/v) to be instilled 2 hours prior to the surgery once in every 10 minutes in the eye to be operated.

SURGICAL TECHNIQUE

- Preoperative measures like consent for surgery, antibiotic eye drops, dilatation of pupil was done.
- Under all aseptic precautions eye painted with povidone iodine and draped, universal eye speculum put
- A superior clear corneal incision made with a 2.8 crescent knife
- Two side ports incisions were then made at 3 o' clock and- 9 0 clock positions. Anterior chamber entered with side port knifes.
- Trypan blue injected into the anterior chamber and continuous curvilinear capsulorrhexis done.
- Hydroxymethyl cellulose is used to fill the anterior chamber and protect the corneal endothelium
- Main port entry made at 12 o clock position and capsular fold removed
- Hydrodissecion and Hydro delineation is performed.

<u>GROUP A: Direct chop technique</u>

- The superficial cortex and epincuclear plate were removed. Next, the phaco probe was used to hold the superior nucleus at a high vacuum setting. The chopper was then inserted through the side port incision and placed slightly to the right of the 6 0'clock position at the edge of the inferior part of the nucleus. The chopper was moved toward the phaco probe to initiate the

nuclear cracking. Both instruments moved in opposite directions, dividing the nucleus into halves. The nucleus is then rotated 90 degrees, the phaco tip impaled in the inferior hemi section of the nucleus and the chopper used to break this half into smaller fragments which are then emulsified. The procedure is the repeated on the superior nucleus till entire lens material is emulsified. Aspiration of the remaining lens cortex with an irrigation/aspiration instrument.

GROUP B:StopandChop technique

- The phaco probe was used to sculpt a central groove that was 90 percent of the nuclear depth. The chopper and the phaco probe were then inserted in the depth of the groove and the posterior plate of the nucleus was cracked in half by laterally moving the 2 instruments in opposite directions. The chopper is then used to break this half into smaller fragments which are then emulsified. Aspiration of the remaining lens cortex with an irrigation/aspiration instrument.
- Injection of viscoelastic material into the anterior chamber followed by insertion of a foldable PCIOL (PMMA) into the capsular bag.
- Viscoelastic material removed and AC wash given
- Intracameral preservative free moxifloxacin instilled
- Eye padded and patched

During the above procedure the following will be noted in both groups-

- Effective phaco time (sec)
- Amount of irrigation fluid used (ml)
- Phaco power/Cumulative Dissipated Energy (%)
- Complications that occurred during the nucleotomy

On the day following surgery

- Best corrected visual acuity (BCVA) will be noted.
- Detailed slit lamp examination will be done.
- IOP will be noted using non-contact tonometer.

The patient will be followed up on:

- The immediate post op day
- One week after surgery
- Four weeks after surgery

Every time, the parameters assessed are:

- Best corrected Visual acuity
- Detailed slit lamp examination
- IOP will be noted using non-contact tonometer

STATISTICAL ANALYSIS:

For the continuous quantitative variables mean and standard deviation will be calculated. For the purpose of comparison if the data is divided into two groups with respect to certain qualitative characteristic, the continuous variables will be compared using suitable tools of statistics like unpaired student's t test. The pre and post treatment measures will be compared using student's paired t test

Discrete variables will be represented by median. Suitable graphs will be used to depict the comparison.

The categorical data will be expressed in terms of rates, ratios and percentages. The association between the outcome, clinical and demographic characteristics will be tested using Chi-square test or Fisher's exact test

RESULTS

The present study was conducted at the Department of Ophthalmology, KLE's Dr.Prabhakar Kore Hospital and Medical Research Centre, Belagavi during the study period, from 1st January 2019 to 31st December 2019 and 96 patients were enrolled. It included patients who were diagnosed with grade III-IV nuclear sclerosis and willing for phacoemulsification with PCIOL implantation, meeting the inclusion criteria. There were assigned to either of the two surgical techniques by computer generated random numbering system.

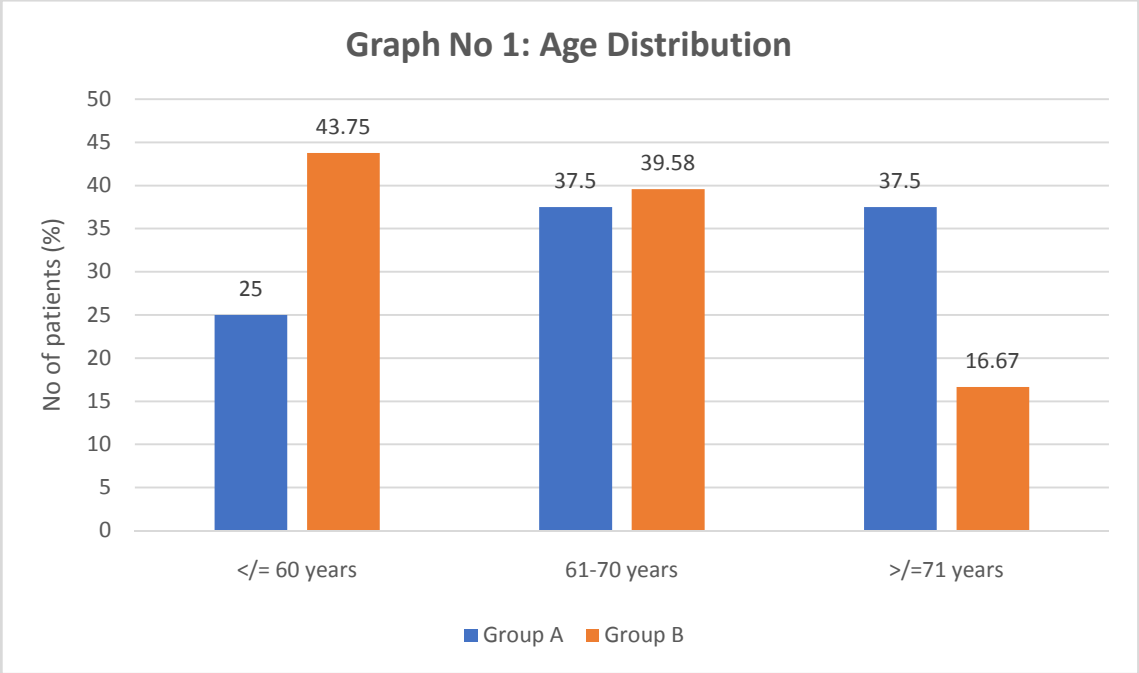
Group A:Phacoemulsification with Direct Chop Technique

Group B : Phacoemulsification with Stop and Chop Technique

Pre-operative Visual acuity, grading of the cataract, Intraoperative effective Phaco time, Cumulative dissipated energy, amount of aspiration fluid used and the post-operative visual acuity and complications were used for data analysis.

Table No. 1: Age Distribution

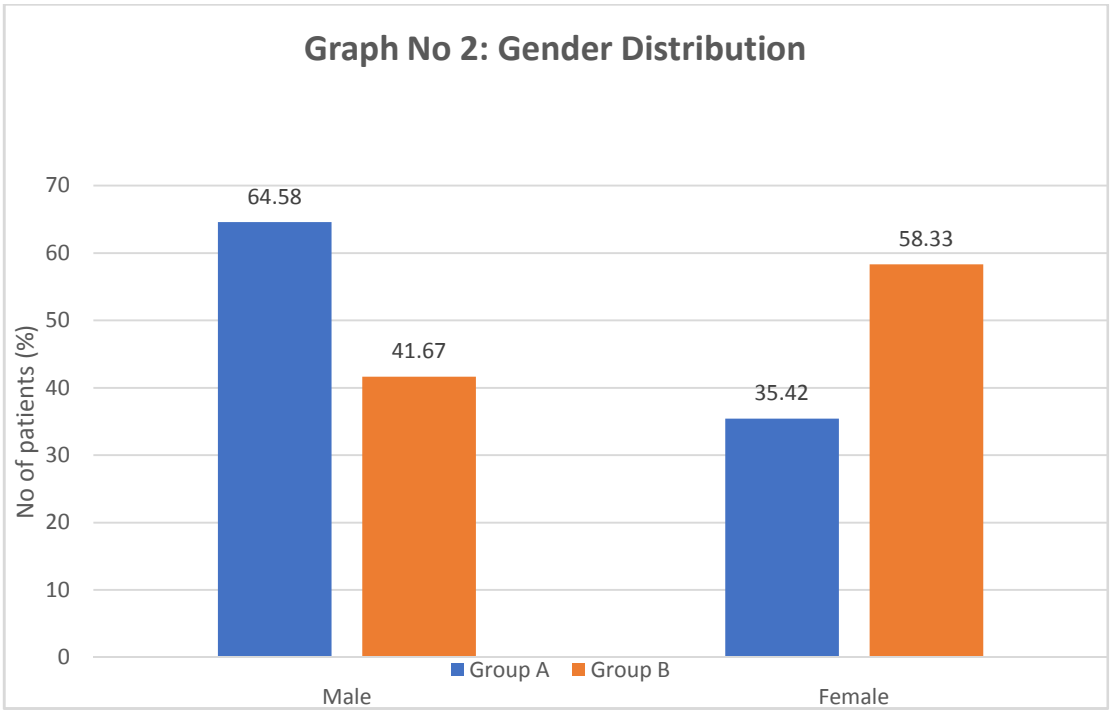
Age (in years)	Group A	Group B
	No. of patients(%)	No. of patients(%)
<60	12(25)	21(43.75)
61-70	18(37.50)	19(39.58)
>71	18(37.50)	8(16.67)
Total	48 (100)	48(100)
Mean Age	67.60	63.17
SD Age	9.11	8.39



In the present study, the mean age in Group A was 67.60 ± 9.11 years and Group B was 63.17 ± 8.39 years and majority of the patients belonged to the range of 61-70 years.

Table No 2 : Gender Distribution

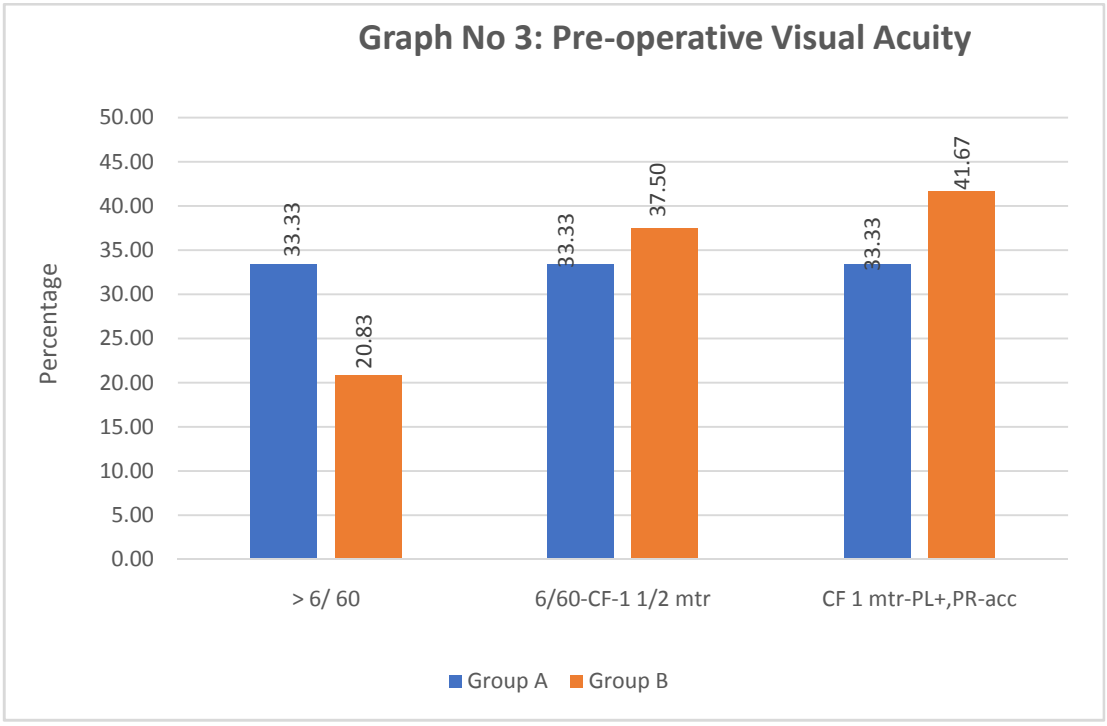
Gender	Group A	Group B
	No. of patients(%)	No. of patients(%)
Male	31(64.58)	20(41.67)
Female	17(35.42)	28(58.33)
Total	48(100)	48(100)



In the present study, 64.58% were male and 41.67% were female with male: female ratio of 1.54:1 in Group A. 35.42% were male and 58.33% were female with male: female ratio of 0.6:1 in group B.

Table No 3:Pre-operative Visual Acuity

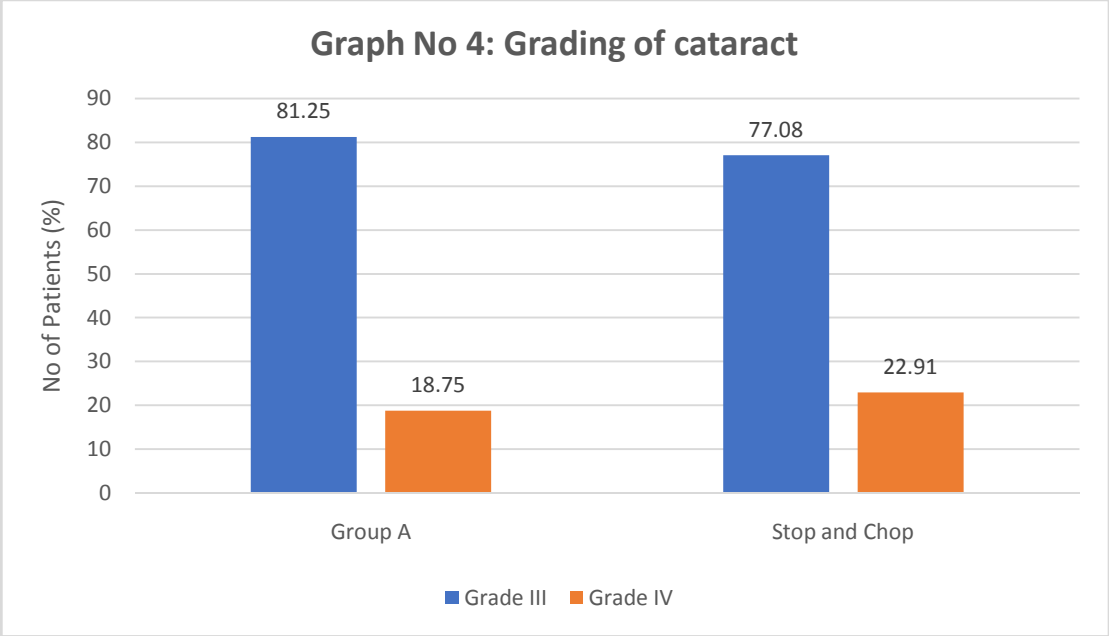
Pre-Op Visual Acuity	Group A	Group B
	No. of patients(%)	No. of patients(%)
>6/60	16 (33.33)	10 (20.83)
6/60-CF 1 ½ M	16 (33.33)	18 (37.50)
CF 1 M-PL+,PR-acc	16 (33.33)	20 (41.67)
Total	48 (100)	48 (100)
Chi-square- 1.9472, P= 0.3780		



In the present study, pre-operative visual acuity in the range of >6/60 was seen in 20.83% (10) patients, 6/60 to CF 1 ½ M in 37.50 % (18) patients and CF1M to PL+,PR-ACC in 41.67 % (20) patients Of Group B. In group A, there was an equal distribution of patients, that is, 33.33 %(16 patients) in all the above three categories .

Table No 4:Pre-operative grading of cataract

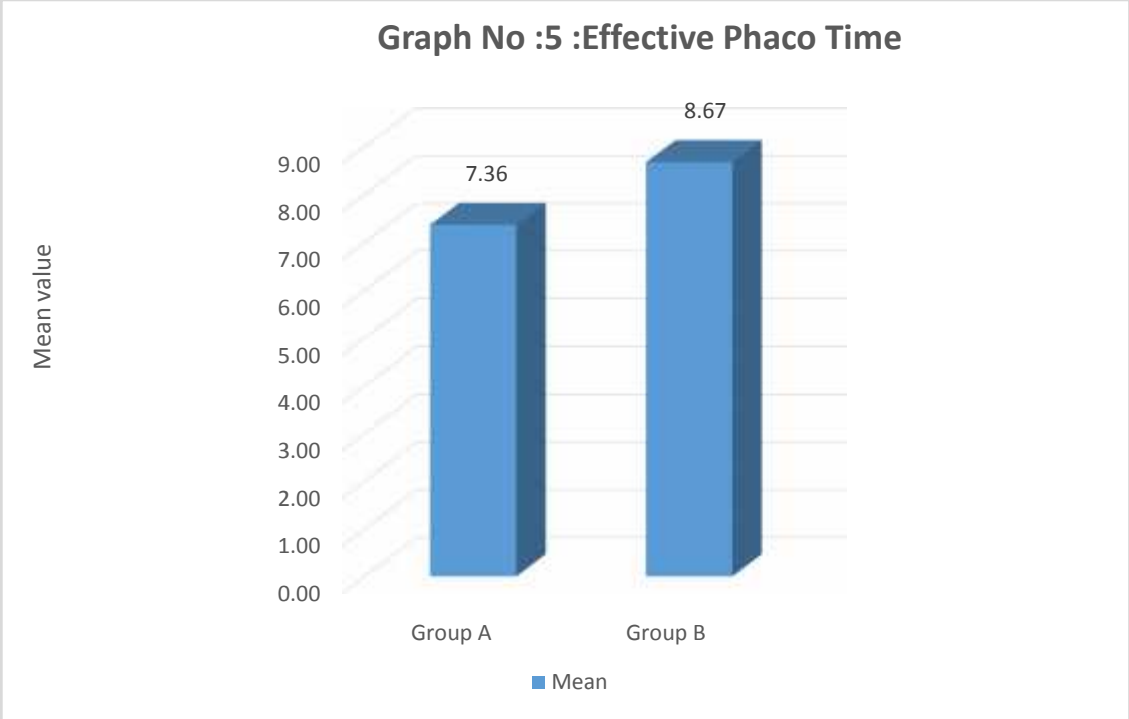
Pre-Op Grading	Group A	Group B
	No. of patients(%)	No. of patients(%)
Grade III NS	39 (81.25)	37 (77.08)
Grade IV NS	9 (18.75)	11 (22.91)
Total	48 (100)	48 (100)



In this study,39 patients (81.25%) in the Group A and 37 patients(77.08%) in the Group B had a nuclear grading of -Grade III. 9 patients (18.75%) in Group A and 11 patients(22.91%) in Group B had a nuclear grading of -Grade IV.

Table No 5: Intraoperative Effective Phaco Time

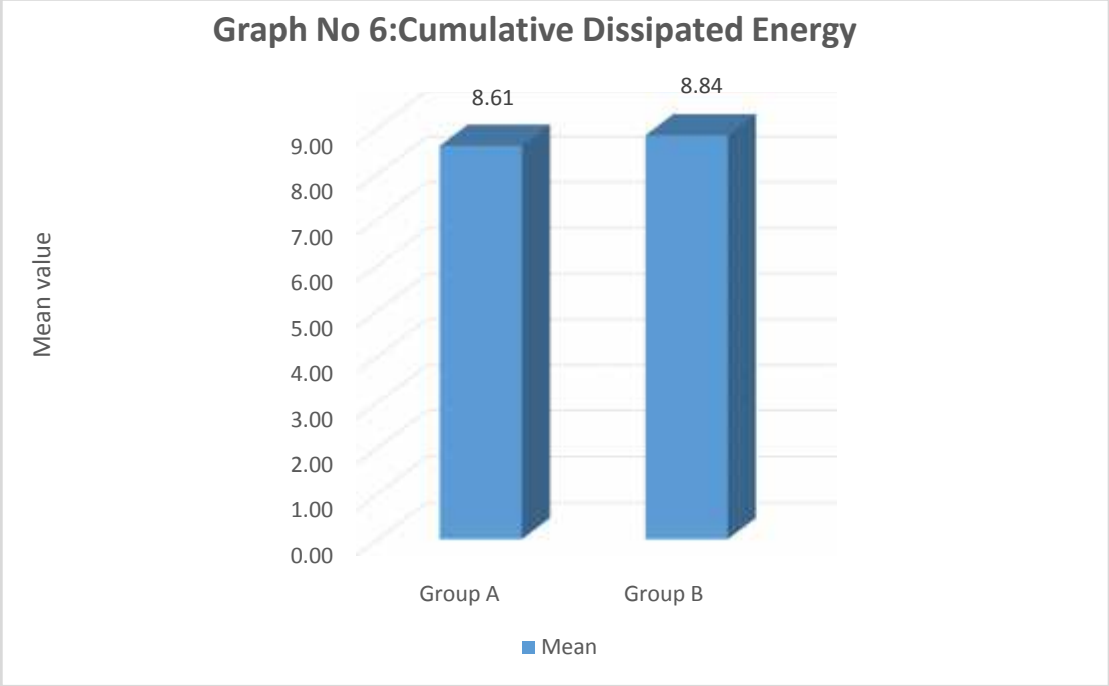
Effective Phaco time	Group A (sec)	Group B (sec)
Mean	7.36	8.67
SD	3.43	5.52
SE	0.50	0.80
t -value : -1.4008, P -value :0.1646		



In this study, mean effective phaco time in Group A was 7.36±3.43 sec and 8.67±5.52 sec in Group B.The difference between the effective phaco time between the two groups has a p value -0.16, which was not statistically significant.

Table No 6: Intraoperative Cumulative Dissipated Energy

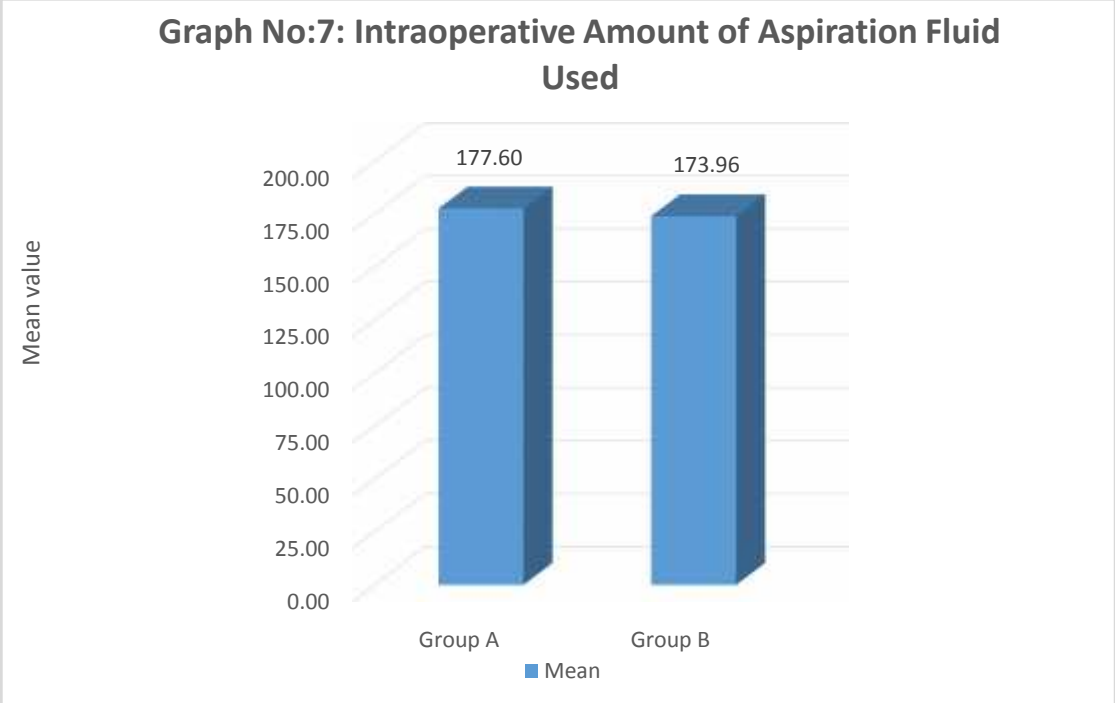
Cumulative Dissipated Energy	Group A (%)	Group B (%)
Mean	8.61	8.84
SD	2.87	3.89
SE	0.41	0.56
t -value : -0.3225, P -value :0.7478		



In the present study, the cumulative dissipated energy (%) in Group A was 8.61±2.87 % and 8.84 ± 3.89 % in Group B.The difference between the cumulative dissipated energy in between the two groups has p value -0.7478, which was not statistically significant.

Table No 7: Intraoperative Amount of Aspiration Fluid Used (ml)

Aspiration Fluid	Group A (ml)	Group B (ml)
Mean	177.60	173.96
SD	20.78	52.95
SE	3.00	7.64
t -value : 0.4440 , P -value :0.6580		

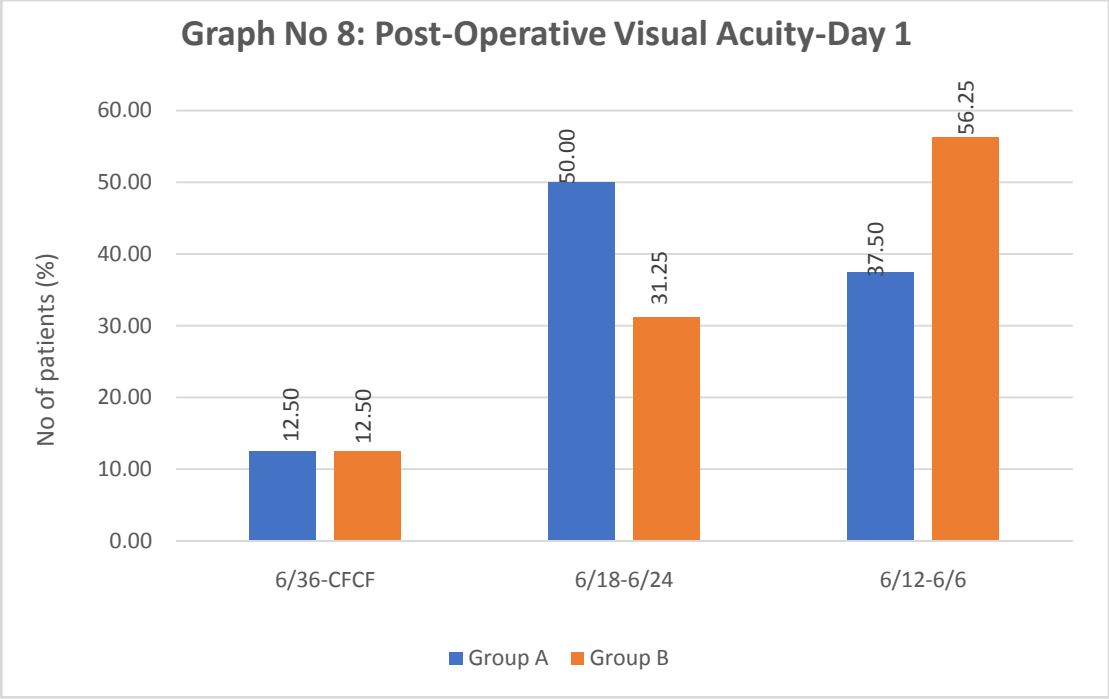


In this study, intraoperative amount of aspiration fluid required in the Group A was found to be 177.60±20.78 ml and Group B had 173.96±52.95 ml.

The difference between the intraoperative amount of aspiration fluid required between the two groups has p value- 0.6580, which was not statistically significant.

Table No. 8: Post-Operative Visual acuity -Day 1

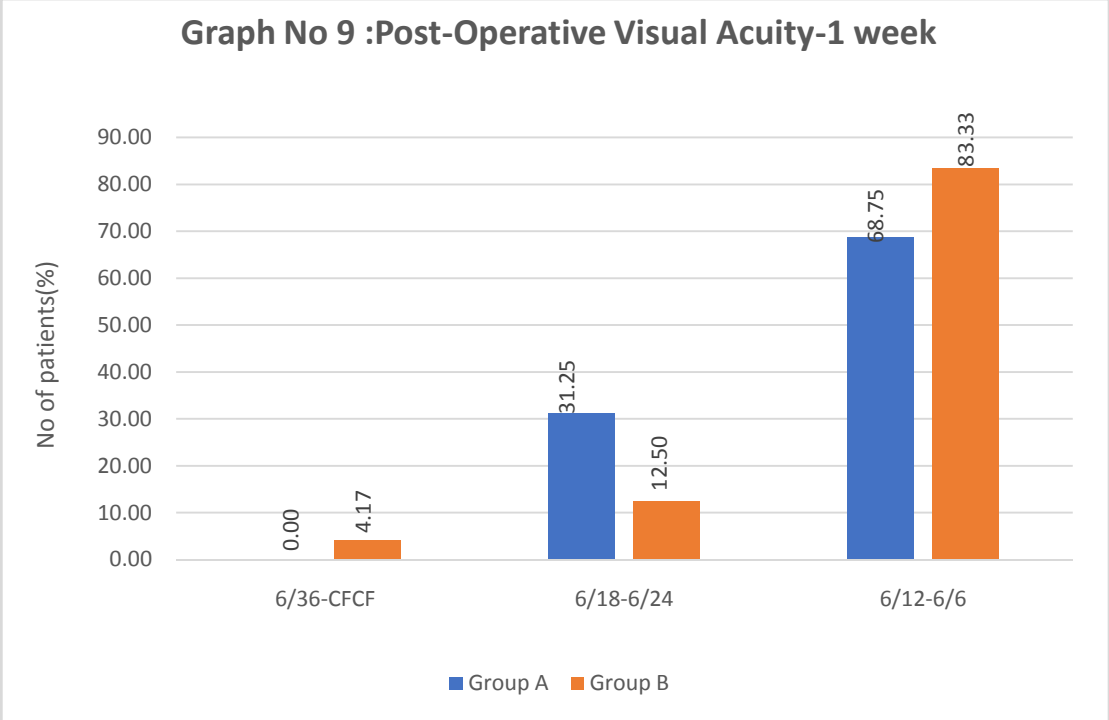
Range of Visual Acuity	Group A	Group B
	No. of patients(%)	No. of patients(%)
6/36-CFCF	6 (12.50)	6 (12.50)
6/18-6/24	24 (50)	15 (31.25)
6/12-6/6	18 (37.50)	27 (56.25)
Total	48 (100)	48(100)
Chi square – 3.8772, P- 0.1441		



In our study, Day 1-post-operatively 12.50 % (6) patients in both Group A and Group B had uncorrected visual acuity ranging from 6/36-CFCF, 50 % (24) patients in Group A and 31.25% (15) in Group B had uncorrected visual acuity ranging from 6/18 – 6/24.In the study,in Group A 37.50% (18) patients and in Group B, 56.25% (27) had visual acuity ranging from 6/6-6/12.

Table No. 9: Post-Operative Visual acuity -1 week

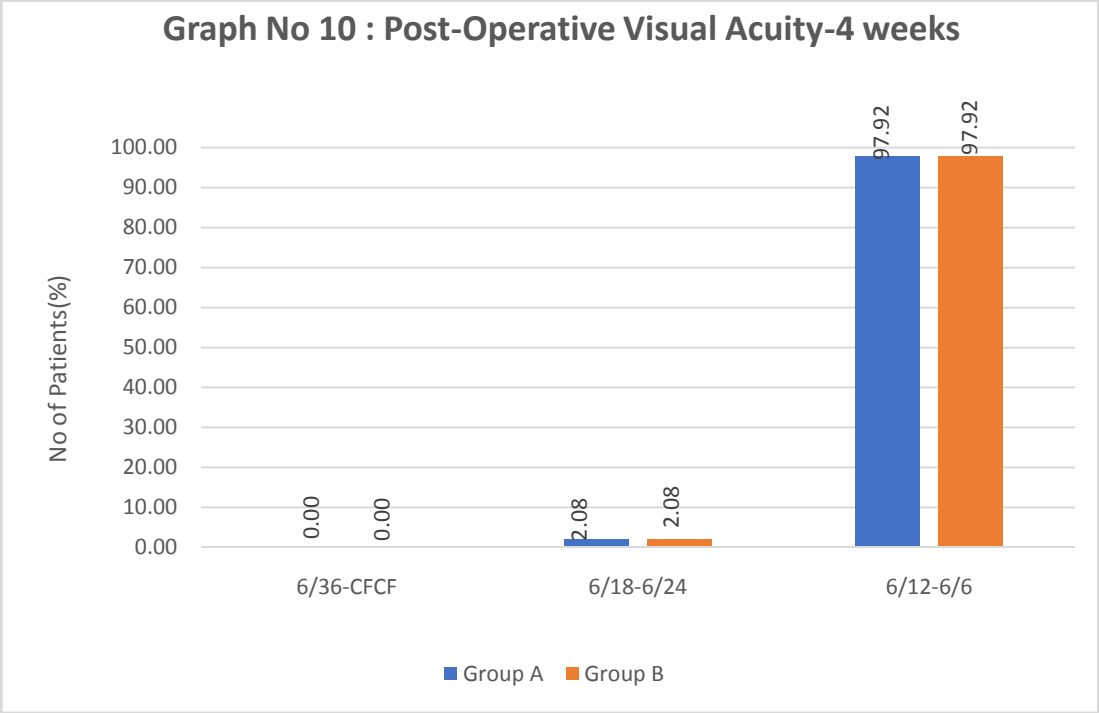
Range of Visual Acuity	Group A	Group B
	No. of patients(%)	No. of patients(%)
6/36-CFCF	0	2 (4.17)
6/18-6/24	15 (31.25)	6 (12.50)
6/12-6/6	33 (68.75)	40 (83.33)
Total	48 (100)	48(100)
Chi square – 6.5284, P- 0.0380*		



In the present study, 1 week post-operatively 4.17 % (2) patients Group B had uncorrected visual acuity ranging from 6/36-CFCF.No patient in Group A had visual acuity between 6/36-CFCF.31.25 % (15) patients in the Group A and 12.50 % (21) in Group B had uncorrected visual acuity ranging from 6/18 – 6/24.In Group A,68.75 % (33) patients and in Group B 83.33 % (73) had visual acuity ranging from 6/6-6/12.

Table No. 10: Post-Operative Visual acuity -4 weeks

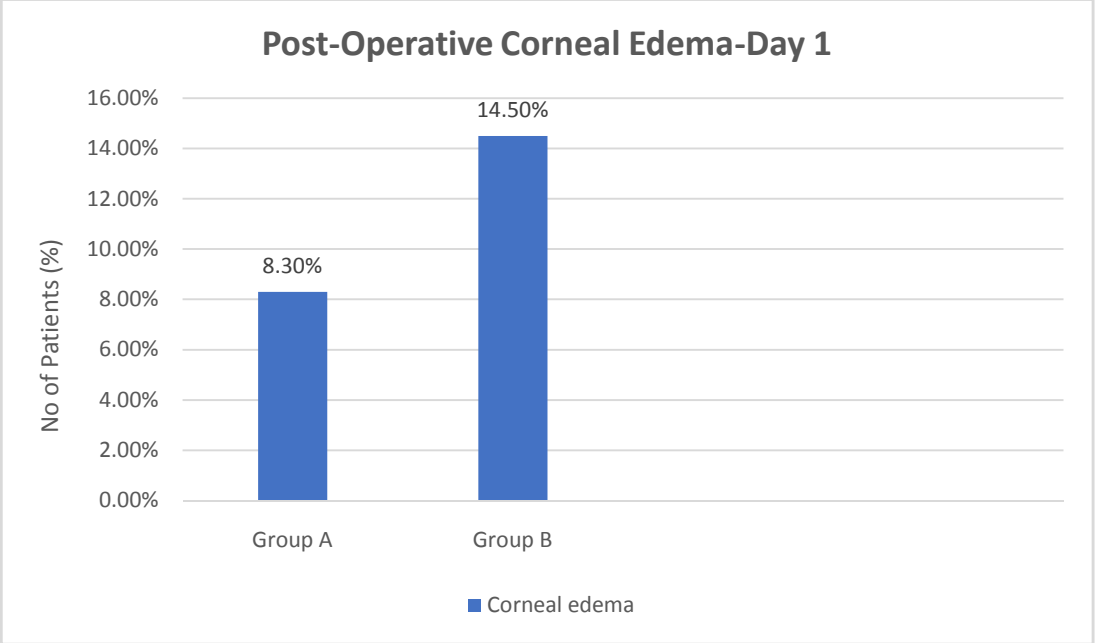
Range of Visual Acuity	Group A	Group B
	No. of patients(%)	No. of patients(%)
6/36-CFCF	0	0
6/18-6/24	1 (2.08)	1 (2.08)
6/12-6/6	47 (97.92)	47 (97.92)
Total	48 (100)	48(100)
Chi square – 0.00, P- 1.000		



In the current study, 4 weeks post-operatively no patient in either Group A or Group B had best corrected visual acuity ranging from 6/36-CFCF.In both Group A and Group B, 2.08%(1) patients had visual acuity ranging from 6/18-6/24 and 97.92% (47) had visual acuity ranging from 6/6-6/12.

Table No 11: Post-Operative Corneal Edema

	Group A	Group B
	No. of patients(%)	**No. of patients(%)**
Corneal Edema	4 (8.3)	7 (14.58)



In this study post operatively, corneal edema was seen in 8.3% in Group A and 14.58 % in Group B. The edema had subsided by the subsequent visit at day 7.

DISCUSSION

The field of cataract surgery was revolutionised with the introduction of phacoemulsification as a surrogate procedure to ECCE by Dr.CharlesKelman. Here the lens was aspirated through a smaller(3-4mm) incision by using an ultrasound-driven needle to emulsify the lens.

Though initially met with hostility, it is now regarded as the safest and preferred method in the modern era. It furnishes shorter recovery time, less surgically induced astigmatism and a more stable AC during surgery. It still continues to get refined and the amount of precision is commendable. So ever since the emergence of phacoemulsification in 1960s, it has replaced the older techniques to be the principal choice of most of the ophthalmic surgeons for an elective surgery.

In phacoemulsification, Cumulative dissipated energy (CDE) measures the amount of ultrasound energy delivered to the eye for emulsification of a cataractous lens during the surgery. This is one of the principle factors which decides the post-operative corneal status, mainly the endothelial cell count. With use of more energy, there will be more deleterious effect on the sensitive endothelial layer of the eye.

Phacoemulsification is found to be ideal technique for Grade II nuclear sclerosis. Here, the process is considerably safe and cumulative dissipated energy that is required is less. As the cataract matures, the nucleus will become denser and will require more energy for its breakdown and subsequent emulsification.

Hard cataracts are all those nuclei which are dense, firm and can withhold pressure. It cannot be easily cracked, crushed and penetrated like a rock solid. The epinuclear plate, the protective layer is usually deficient here and along with the

sparsity of the surrounding cortex, weakness of the zonular apparatus and laxity of the capsule, the risk of injury to the surrounding structures during surgery is amplified. So, when you have to deal with a dense cataract, it is quite challenging and is associated with many problems that can arise due to the use of more ultrasound energy mainly, damage to the corneal endothelium.[48] Hayashi and co-authors[68]found that the age, small pupils, hardness of the nucleus, greater infusion volume and greater ultrasound energy were the main culprits for damage to corneal endothelium.

Phacoemulsification can promote damage to the corneal endothelium by various mechanisms. It can be due to the turbulence created by fluid movement, irrigation flow, ultrasound energy ,trauma during instrumentation and by release of free radicals.[69]Also it is believed that a longer phacoemulsification time and use of greater amount of power can have a direct inimical effect on the corneal endothelium. This iatrogenic trauma can be tackled by better instrumentation, finer viscoelastic devices, and refinement in the surgical techniques and Intraocular lenses.[70]

It was Akahoshi who introduced pre-chopping techniques in view of reducing the use of ultrasound energy for fragmentation and in turn reducing the effective phaco time, power used and the resultant complications during phacoemulsification. However, when it comes to dealing with nuclei that is hard, the use is limited.

An older technique employed was that of divide and conquer technique. Here four trenches were sculptured and the nucleus subsequently cracked into four fragments. It required additional phaco energy for nuclear sculpturing for division before the fragments were emulsified.[12]This led to the introduction of other nuclear chopping techniques for reducing the energy use and thereby the post-operative complications that may arise.

The stop and chop technique introduced by Koch and Katzen[71],initiate the lens fragmentation by creation of a central groove, which furnish space and assist the separation of posterior plate. Then the cracking is put to a halt and chopping of the remaining nucleus is carried out. This construction of a central groove before commencement of the procedure is the main differentiating factor between phaco chop technique and stop and chop technique.[16] Hence, the cracking of a hard nucleus is easier with this technique and subsequent fragmentation and emulsification is put at ease. So, the time duration of the procedure can be cut short. However, it comes at the expense of expenditure of more ultrasound energy, which can adversely affect the endothelial cell count.

The concept of phaco chop was introduced by Nagahara in the year 1993[16].This is a nuclear separation procedure in which the cleavage is along the natural planes of the lens. This technique can narrow down the phaco time and power as phaco energy is used mainly for emulsification of the fragments and the nuclear dissection into fragments is done by manual chopping.[71]Here, difficulty may be faced during initial breaking of the hard nucleus. More amount of stress may fall up on the zonular apparatus and can result in zonular dehiscence. Also, there will be less space available in the bag for manipulation at the initial steps and that would make the process of separation of fragments difficult. This can cause injury to cornea and can even result in folds in descemet's membraneand corneal oedema. But nevertheless, the less amount of energy requirement is still highlighted as the main advantage. Along with that, the introduction of different types of choppers have made the process easier.

Many studies have equated the various techniques of nuclear chopping with the standardized phacoemulsification procedure .However a comparative study of the older technique of stop and chop and direct chop is rare in the literature.

This study was hence formulated with the aim of evaluating and comparing the intra-operative and post-operative effects of two surgical techniques: direct chop and stop and chop in phacoemulsification of grade III-IV nuclear sclerosis.

The present study was conducted at the Department of Ophthalmology, KLE'S Dr.Prabhakar Kore Hospital and Medical Research Centre, Belagavi during the study period, from 1st January 2019 to 31st December 2019 and 96 patients were enrolled. It included patients who were diagnosed with grade III-IV nuclear sclerosis and willing for phacoemulsification with PCIOL implantation, meeting the inclusion criteria. They were assigned to either of the two surgical techniques by computer generated random numbering system.

Group A :Phacoemulsification with Direct Chop Technique

Group B : Phacoemulsification with Stop and Chop Technique

In the present study, the mean age in Group A was 67.60 ± 9.11 years and Group B was 63.17 ± 8.39 years and 63.3% of the patients were more than 60 years of age.

In a study conducted by Vajpayee, which compares phacoemulsification using direct chop and stop and chop nucleotomy techniques, the mean patient age in the direct chop group was 61.47 ±6.77 years and 63.24 ± 8.10 years in the stop-and-chop group. This shows a similar age group of patients as our study. Cataract usually goes into maturation when people neglect it at the early stages and results in presentation at

a later date with a denser cataract which is more challenging from the treatment point of view.

In the present study, it was noted that 51.83 % (51) patients were male and 46.16% (45) patients were female. So, the gender distribution was almost equal between the two genders and between the two groups in this study

According to the earlier studies, women have a higher rate of cataract than men. The possible explanations put forward are higher life expectancy in female population and women are less vocal regarding their health issues and end up presenting with a denser cataract than male population. However, this variation in gender distribution did not have any effect on the post-operative results in our study.

In the present study, pre-operative visual acuity in the range of >6/60 was seen in 20.83% (10) patients, 6/60 to CF 1 ½ M in 37.50 % (18) patients and CF-1M to PL+,PR-ACC in 41.67 % (20) patients Of Group B. In group A, there was an equal distribution of patients, that is, 33.33% (16 patients) in all the above three categories. Most patients thatis 73% patients had pre-operative visual acuity less than 6/60 in this study.

Studies by Can I et al[16] and Vajpayee et al [72]included patients presenting with nuclear sclerosis of similar grades and having visual acuity of < 6/60 .

A study by Zhao[73] showed the pre-operative visual acuity for patients with hard cataract to be 0.11± 0.09 concluding that grade IV dense cataracts usually present with visual acuity of less 6/60. So even in our study, majority had vision less than 6/60 and underwent phacoemulsification for the same. The low vision here is indicative of denser cataract in these patients.

In this study, 39 patients (81.25%) in the Group A and 37 patients(77.08%) in the Group B had a nuclear grading of -Grade III. 9 patients (18.75%) in Group A and 11 patients(22.91%) in Group B had a nuclear grading of -Grade IV. It was seen that there was a similar distribution of patients with both Grade III and Grade IV in both the comparison groups in this study.

In a study by Park J, the patients were initially divided based on Nuclear sclerosis grading(II-IV) and then randomly subdivided into direct chop, stop and chop or divide and conquer groups. A study by Izzet can showed a nuclear density of 2.6± 0.9 in the direct chop group and 2.4 ± 0.8 in the stop and chop group. The objective of focusing mainly on hard cataract in this study is to find out the difficulties faced as well as the variations in the intraoperative parameters when the cataract encountered is a dense one.

In the present study, the intraoperative mean effective phaco time in Group A was 7.36±3.43 sec and in Group B was 8.67±5.52 sec.

A study by Vajpayee showed a mean effective phaco time of 27±18 seconds inPhaco chop group and 28 ± 16 seconds in stop and chop group ,where as a study by Izzet can demonstrated an effective phaco time of 14.9± 11.8 sec in the direct chop group and 22.3± 14.2 in the stop and chop group. A greater effective phaco time implies longer duration of ultrasound energy transfer and in turn point towards a detrimental effect on corneal endothelium.The study by Vajpayee showed no significant difference between the two groups in terms of effective phaco time, whereas Izzer Can concluded phaco chop to be the better technique on comparison.

A study by Park et al[74] found that in case of moderate nuclear density, both the phaco chop and stop-and chop technique were equally efficacious in the nucleus management. Where as in case of dense cataracts, the phaco chop technique required less effective phacoemulsification time than the stop and chop technique (3.86 +/- 4.18 vs 6.70 +/- 5.43 seconds; P = .01). This was similar to the results of our study with phaco chop have less mean effective phaco time. However, it wasn't statistically significant.This reduced value compared to other studies could be due to the use of venturi machine at our set up.

In this study,the mean cumulative dissipated energy (phaco power-%) in Group A was 8.61±2.87 % and in Group B was 8.84 ± 3.89 sec.

In a study published by Vajpayee the phaco power was 18.7 ± 5.0 in the phaco chop(direct chop)group and 20.0 ± 6.2 in the stop and chop group. According to the study by Park J et al the phaco power among the grade IV cataract was 15.1± 3.8 in phaco chop group,19.7± 4.3 in divide and conquer group and 18.1 ± 5.6 in the stop-and-chop group.These studies point towards a greater energy consumption in divide and conquer followed by stop and chop and the least energy comsumption in phaco chop procedure. The above observation is similar to the findings from our study. However, there is no statistically significant difference between the two methods in our study as far as the phaco power is concerned.

In this study, amount of intraoperative aspiration fluid required in Group A was 177.60±20.78 ml and in Group B was 173.96±52.95 ml(p-0.65). These values were quite similar between the two groups and there was no statistical significance noted.

The study by Juwan Park showed that the aspiration fluid usage was 82.3± 22.8 ml in grade IV nuclear sclerosis as per the phaco chop technique and 112.0± 39.7 ml in the stop-and-chop technique. In the same study, in case of grade III nuclear sclerosis the fluid usage was 76.4± 19.4 ml with phaco chop technique and 82.6 ± 16.4 ml with stop-and-chop technique. Based on this, it can be concluded that a greater amount of aspiration fluid is required for a denser cataract and more if we are doing a stop-and -chop technique as compared to direct chop technique.

In a study by Izzet Can et al[16]the phaco chop and stop and chop nucleotomy techniques were compared. The results showed that the phaco power, effective phaco time and even post-operative complications like corneal edema was significantly lower in the phaco chop group.

The studies which compare these two techniques are quite sparse. The results obtained by Vajpayee et al [72] with 20 patients in each group was similar to our study. They found that there were no significant differences between the phaco-chop and stop-and-chop technique in terms of any preoperative, intraoperative, or postoperative parameter.

In our study, Day 1-post-operatively 12.50 % (6) patients in both Group A and Group B had uncorrected visual acuity ranging from 6/36-CFCF, 50 % (24) patients in Group A and 31.25% (15) in Group B had uncorrected visual acuity ranging from 6/18 – 6/24. In the study, in Group A 37.50% (18) patients and in Group B, 56.25% (27) patients had visual acuity ranging from 6/6-6/12.

Only 12.50 % patients here had a vision less than 6/36, this could be due to the immediate post-operative corneal edema, indicative of endothelial cell loss. 46% of

the patients had good visual outcome ranging between 6/12-6/6 and it was found to be similar in both groups.

In the present study, 1 week post-operatively 4.17 % (2) patients Group B had uncorrected visual acuity ranging from 6/36-CFCF.In Group A, all the patients had a visual acuity more than 6/36 at 1 week .31.25 % (15) patients in the Group A and 12.50 % (21) patients in Group B had uncorrected visual acuity ranging from 6/18 – 6/24. In Group A ,68.75 % (33) patients and in Group B 83.33 % (73) had visual acuity ranging from 6/6-6/12.

At the 1 week follow up, the 12.50 % who initially had less vision showed improvement. This shows that there was no long-lasting deleterious effect on the corneal endothelial cells due to these techniques in either of the two groups.

At 4 weeks post-operatively, the best corrected visual acuity was found to be between 6/12-6/6 in 97.92% patients in both Group A and Group B. There was no significant difference between the two groups (P value- 1.0000)

In a study by Park J ,the best corrected visual acuity at the end of two months was 0.85 ± 0.09 in the dense cataract by phaco chop,0.85± 0.14 by divide and conquer and 0.86± 0.12 by stop and chop. So all the three techniques were equally efficacious when post-operative visual acuity is compared and all the patients had a good visual outcome. These results are comparable with our study.

In our study, only one patient in the Group B had visual acuity of 6-18-6/24 at the end of 4 weeks and it was a case of diabetic retinopathy with macular edema which was not picked up earlier due to a dense cataract hindering the pre-operative detailed posterior segment visualization. In group A, one patient due to persisting

corneal edema, had a visual acuity was between 6/18-6/24 at 4 weeks. Rest all patients had a visual acuity between 6/6-6/12 on evaluation at 4 weeks.

In a study by Zhao et al[73],they compared the pre chopping method using reverse chopper to stop and chop technique .The effective intraoperative phaco time, corneal edema, BCVA and rate of endothelial cell loss were assessed. The effective phaco time was found to be shorter in the reverse chopper group($p=0.00$) and the corneal edema was less($p<0.01$).Also it was found that the endothelial cell loss was lower and BCVA was higher among the reverse chopper group. So, it was found better than stop and chop technique in hard cataracts.

In this study post operatively, corneal edema was seen in 8.3% patients in Group A and 14.58 % patients in Group B. The edema had subsided by the subsequent visit at day 7. This indirectly explains that there was no significant loss of endothelial cells.

In a study by Mierzejewski et al[75],comparison between the divide and conquer and stop and chop techniques were performed. The study concluded that ultrasound time was significantly shorter in patients operated with "stop and chop" technique. On post-op Day 1, better visual acuity and smaller amount of corneal edema were also observed in this group. The number of intraoperative complications in both groups were low.In a study by shaw at al [76],the overall complication rate in people who underwent phacoemulsification was 0.92%. This comprised 0.34%, posterior capsule rupture without vitreous loss; 0.50%, anterior vitrectomy; and 0.08%, dropped lens fragment. In another study by Haripriya et al[46] ,the complication rate was 1.11% for phacoemulsification when compared with manual SICS. However in our study there was no intraoperative or post-operative complication noted in any of the 96 eyes.Only

a transient corneal edema which lasted for few weeks was the only observation post operatively.

The direct chop technique is more complex at the technical level with a longer learner curve and it is more commonly associated with tears in the rhexis as shown by the study of Vajpayee et al[72]. Also, difficulty in instrumentation and more stress on the zonular apparatus are its demerits. Though the stop and chop technique make use of more ultrasound energy it is easier in execution. The sculpturing of the initial trenches makes the whole process of nuclear fragmentation simpler and if performed meticulously, there won't be any lasting loss of endothelial cells and good post-operative vision is noted. Hence it is best left to surgeon's choice that which technique he wants to implement in a particular case.

***Limitations of the study*:**

All cases in the present study were followed up for a duration of 4 weeks, while most other studies have followed up their patients up to 2 or 3 months. The measurement of corneal endothelial cell density would have given a more specific result to the study in terms of post-operative complications. The unavailability of a specular microscope at our center affected the assessment of the technique in terms ofthe side effects of energy usage. Also, the comparison of corneal thickness pre operatively and post operatively would have given a better way of assessing thecorneal edema. These limitations are overcome by meticulous post – operativeexamination for evaluation of corneal edema and post-operative visual assessment

CONCLUSION

The present study was conducted at the Department of Ophthalmology, KLE's Dr.Prabhakar Kore Hospital and Medical Research Centre, Belagavi during the study period, from 1st January 2019 to 31st December 2019 and 96 patients were enrolled. It included patients who were diagnosed with grade III-IV nuclear sclerosis and willing for phacoemulsification with PCIOL implantation, meeting the inclusion criteria. There were assigned to either of the two surgical techniques by computer generated random numbering system. Group A patients underwent Phacoemulsification with Direct-Chop Technique whereas, Group B patients had Phacoemulsification with Stop-and-Chop Technique

The following conclusions were drawn from the study:

- In the present study, the mean age in Group A was 67.60 ± 9.11 years and Group B was 63.17 ± 8.39 years and 63.3 % patients had vision less than 6/60. The late presentation results in maturation of cataract and more patients presenting with a dense nucleus as seen in our study.

- In this study,73% patients had a pre-operative visual acuity less than 6/60 and this was co-relating with the fact that 79% patients presented with a nuclear grading of Grade III nuclear sclerosis and 31 % had Grade IV nuclear sclerosis.

- The mean effective phaco time in Group A was 7.36±3.43 sec and in Group B 8.67±5.52 sec(p-<0.16). Study by Vajpayee showed no difference between the two groups in terms of mean effective phaco time .

whereas Izzet Can concluded phaco chop to be a better technique. The results of our study showed that phaco chop required less mean effective phaco time, but it was not statistically significant.

- In this study, the cumulative dissipated energy (phaco power %) in Group A was 8.61±2.87 % and in Group B 8.67±5.52 sec(p-<0.16). A denser cataract means more energy consumption for breaking down the nucleus into fragments. Here in this study more power was required for stop and chop technique, however there was no statistically significant difference between the two groups.
- In this study, amount of intraoperative aspiration fluid required in Group A group was 177.60±20.78 ml and in Group B 173.96±52.95 ml(p-0.65). This was found to be equal between the two groups and no statistical significance noted.
- In our study, Day 1 post-operatively, only 12.5% patients in both Group A and Group B had a visual acuity between 6/36-CFCF and it was mainly due to the immediate post-operative edema. It was found to be resolved at the subsequent evaluation at 1 week. At 1 week post-operatively,76% patients had a visual acuity between 6/12-6/6.
- At 4 weeks post-operatively, the best corrected visual acuity was found to be between 6/12-6/6 in 97.92% patients in both direct chop and stop and chop groups. There was no significant difference between the two groups (P value-1.0000)

- In our study, only one patient in the Group B had visual acuity of 6-18/6/24 at the end of 4 weeks and it was a case of diabetic retinopathy with macular edema

which was not picked up earlier due to a dense cataract hindering the pre-operative detailed posterior segmentvisualization. In group A, one patient due to persisting corneal edema, had a visual acuity between 6/18-6/24 at 4 weeks. Rest all patients had a visual acuity of 6/6-6/12 on evaluation at 4 weeks.

- In this study post operatively, corneal edema was seen in 8.3% in Group A and 14.58 % in Group B. The edema had subsided by the subsequent visit at day 7. This indirectly explains that there was no significant loss to the endothelial cells.

These findings concluded that no significant difference existed between the direct chop and stop and chop when you compare the intraoperative and post-operative parameters. Hence proving both the methods are equally efficacious for nuclear management in hard cataracts.

There have been a number of studies offering innovative nucleus management techniques for hard cataracts. Each advocates a different technique of approaching the nucleus. Eventually, the individual surgeon must choose his or her own approach for phacoemulsification in hard cataract.(15)

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ANNEXUREI

ETHICAL CLEARANCE CERTIFICATE

K.L.E. ACADEMY OF HIGHER EDUCATION AND RESEARCH
(Deemed – to- be- University)
Accredited 'A' Grade by NAAC (2nd Cycle) Placed in Category 'A' by MHRD (GoI)
JAWAHARLAL NEHRU MEDICAL COLLEGE,
NEHRU NAGAR, BELAGAVI-590010 (KARNATAKA-INDIA)
Website: http//www.jnmc.edu
E-Mail : domc@jnmc.edu
Phone: (+ 91-(0)831 Office : 2472550
Principal: 2471701
Fax No. +91 (0)831 – 2470759

Ref: MDC/DOME/ 58 **Date: 24/11/2018**

To,

REG. NO. BK0118003
PG student in Ophthalmology,
J.N.Medical College,
BELAGAVI.

Sub: Institutional Ethical Clearance for the study.

With reference to the above, we wish to inform you that your proposed research project titled **"COMPARATIVE STUDY BETWEEN DIRECT CHOP & STOP – AND CHOP IN PHACOEMULSIFICATION SURGERY OF GRADE III-IV NUCLEAR SCLEROSIS IN PATIENTS ADMITTED IN KLE'S DR. PRABHAKAR KORE HOSPITAL AND MEDICAL RESEARCH CENTRE BELAGAVI: ONE YEAR RANDOMISED CONTROL STUDY",** is ethical and justifiable. The proposed research project has been cleared by the JNMC Institutional Ethics Committee on Human Subjects Research.

(Dr. Arathi Darshan)
Member Secretary
JNMC Institutional Ethics Committee
on Human Subjects Research,
J.N.Medical College, Belagavi.

(Dr. Roopa M Bellad)
Chairman,
JNMC Institutional Ethics Committee
on Human Subjects Research,
J.N.Medical College, Belagavi.

ANNEXURE II: CONSENT FORM

CONSENT FOR PARTICIPATION IN RESEARCH STUDY

STUDY ID NO: _____

TITLE OF THE STUDY:

COMPARATIVE STUDY BETWEEN DIRECT CHOP AND STOP AND CHOP IN PHACOEMULSIFICATION SURGERY OF GRADE III-IV NUCLEAR SCLEROSIS IN PATIENTS ADMITTED IN KLE'S DR.PRABHAKAR KORE HOSPITAL AND MEDICAL RESEARCH CENTRE BELAGAVI: ONE YEAR RANDOMISED CONTROL STUDY

PRINCIPAL INVESTIGATOR:REG. NO. BK0118003

GUIDE: Dr. _____

INTRODUCTION AND PURPOSE:

This study is designed to study the efficacy and safety of two different phacoemulsification techniques direct chop and stop and chop for grade iii-ivnuclear sclerosis. When now phacoemulsification is popularly preferred by most of the ophthalmologic surgeons such a study will prove useful in assessment of hard cataract phacoemulsification.

PROCEDURE:

I request you to kindly participate in the study titled 'COMPARATIVE STUDY BETWEEN DIRECT CHOP AND STOP AND CHOP IN PHACOEMULSIFICATION SURGERY OF GRADE III-IV NUCLEAR SCLEROSIS IN PATIENTS ADMITTED IN KLE'S DR.PRABHAKAR KORE HOSPITAL AND MEDICAL RESEARCH CENTRE BELAGAVI : ONE YEAR RANDOMISED CONTROL STUDY"

If you agree to participate in the study please provide the details pertaining to the study. We will check visual acuity, anterior segment, optic disc changes and intraocular pressure, intraoperative evaluation of phaco time, ultrasound energy and amount of irrigation fluid used and post-operative evaluation of the visual acuity,anterior segment and post segment on day 1,1 week and 4 weeks

BENEFITS: Results will help to study and compare between two different techniques of phacoemulsification

RISKS: No proven side effects

ALTERNATIVES:

If patient is not willing to take part in the study, his / her treatment or any other further investigations the patient wants to undergo, in future, in KLE will not be affected by his / her decision.

VOLUNTARY PARTICIPATION/WITHDRAWAL:

Taking part in this study is voluntary. I may choose not to take part in this study, or if I decide to take part I can later change my mind and withdraw from the study. My decision will not change the present or future health care or other services that I receive. The study doctor or the sponsor may stop my participation in this study. I will tell of any important new findings that may change my willingness to continue to take part. If I choose not to take part in the study I will receive the standard treatment for patients with my condition.

COSTS: NIL

COMPENSATION:In the event that I become injured as a result of taking part in this study, treatment will be offered to me. No reimbursement, compensation or free medical care is given.

CONFIDENTIALITY:

All information collected about me during the course of the study will be kept confidential to the extent permitted by the law. The code numbers will identify me in this research record. Information from this study may be published but my identity will be confidential in any publication.

CONSENT TO PARTICIPATE IN RESEARCH STUDY:

I voluntarily agree to take part in this study by signing on the line below. I may withdraw at any time. I am not giving up any of my legal rights by signing this form. My signature below indicated that I have read this entire consent form or it has been read to me, and has been explained to me in my vernacular language and had all my questions answered. I will be given a copy of this consent form.

Signature /Left Thumb print of the Participant or legally authorized representative.

Participant's Name ……..

Signature/ Left Thumb impression: ……..…….

Name of the legally authorized representative: …….

Signature/ Left Thumb impression: ……...……..

Witness's Name: ……

Signature/ Left Thumb impression: …….

Investigators name and Signature: ……

Date and Place: …….

Information from this study may be published but my identity will be confidential in any publication.

QUESTION:

If any enquiries in the future or in case of research related injury illness, you may contact following person.

1) PRINCIPAL INVESTIGATOR: **REG. NO. BK0118003**, Post graduate student, Department of Ophthalmology, J N Medical College, Belagavi.

2) GUIDE: Dr._____ ., Professor, Department of Ophthalmology, J N Medical College, KLE University, Belagavi.

3) Dr.ROOPA BELLAD M.D.DCH, Professor of Pediatrics, Chairman of JNMC Institutional Ethics Committee on Human Subjects Research, J N Medical College, Belagavi.

ANNEXURE III

PROFORMA

GENERAL INFORMATION

IP NUMBER: OP NUMBER: PATIENT ID NUMBER:

NAME:

_____

AGE: _____ GENDER: F/M CONTACT NUMBER:

ADDRESS: _____

_____

_____

DATE OF ADMISSION: _____ DATE OF DISCHARGE:

_____

Is the patient eligible for the study? YES/NO

Has informed consent been given? YES/NO

Final result information:

1. Ineligible
2. Eligible –Refusal
3. Eligible – Participating

CHIEF COMPLAINTS

Diminution of vision: RE/LE/BOTH EYES

Duration: RE: _____ days/months/years

LE: _____ days/months/years

HISTORY OF PRESENTING ILLNESS

Diminution of vision: Gradual/Sudden

Progressive/Static

Painless/Painful

For distance/For near/For both distance and near

Diplopia: Present/Absent

Coloured halos: Present/Absent

Black spots before the eyes: Present/Absent

Watering: Present/Absent

Redness: Present/Absent

Discharge: Present/Absent

Clear/Whitish

Serous/Mucoid

Spectacle use: Distance/Near/Both

Duration: _____ days/months/years

Last refraction done: _____ days/months/years back

PAST HISTORY

Ocular surgery: Yes/No Type of Surgery: _____

Duration: _____ days/months/years

Diabetes: Yes/No

Duration: _____ days/months/years

Hypertension: Yes/No

Duration: _____ days/months/years

Any other medical disorders:

_____

_____

PERSONAL HISTORY

Smoking: Yes/No

Duration: _____ days/months/years

Alcoholism: Yes/No

Duration: _____ days/months/years

Other addictions: Yes/No

Duration: _____ days/months/years

GENERAL PHYSICAL EXAMINATION

General appearance: Well-built/Moderately built/Poorly built/Emaciated

Pallor: Present/Absent If present: Mild/Moderate/Severe

Pulse: _____ beats/minute BP: _____ mmHg

Temperature: _____ ^{o}F Respiratory Rate: _____/minute

SYSTEMIC EXAMINATION

CVS: Normal/Abnormal

Specify:

_____

RS: Normal/Abnormal

Specify:

_____

CNS: Normal/Abnormal

Specify:

_____

GIT: Normal/Abnormal

Specify:

_____

OCULAR EXAMINATION

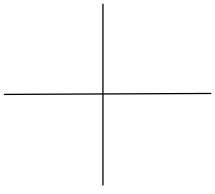
Head posture: Erect/Tilted

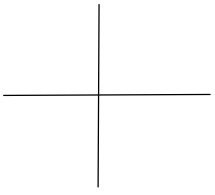
Visual axis: Parallel/Deviated

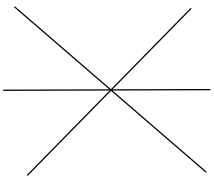
Facial symmetry: Symmetrical/Asymmetrical

Extra-ocular movements: Normal/Restricted/Partially restricted

RE: LE: Binocular:





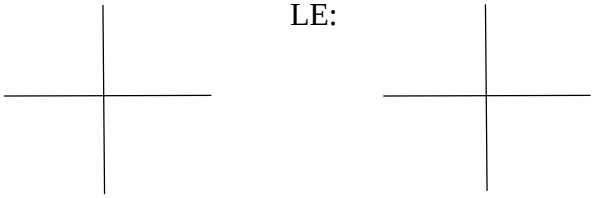


VISUAL ACUITY:

	RE		LE	
DISTANT				
PINHOLE				
NEAR				
AIDED				

REFRACTION/RETINOSCOPY:

RE: LE:



PRESCRIPTION	SPHERICAL	CYLINDRICAL	AXIS	BCVA
RE				
LE				

	OD	OS
LID		
ADNEXA		
CONJUNCTIVA		
SCLERA		
CORNEA		
ANTERIOR CHAMBER		
IRIS		
PUPIL A. Size	_____ in mm	_____ in mm

B. Shape C. Direct D. Indirect E. Near reflex	Present/Absent Present/Absent Present/Absent	Present/Absent Present/Absent Present/Absent
LENS	Clear/Opaque Aphakia/Pseudophakia Immature/Mature/Hypermature NS/CC/PSC Grade – I / II / III / IV	Clear/Opaque Aphakia/Pseudophakia Immature/Mature/Hypermature NS/CC/PSC Grade – I / II / III / IV

Fundus Examination	OD	OS
GLOW		
MEDIA		
DISC		
1. Size		
2. Shape		
3. Colour		
4. NRR		
5. Vessels		
6. Lamellar Dot Sign		
7. Haemorrhagic Spots		
8. Other Signs		
C:D RATIO		
BLOOD VESSELS		
BACKGROUND		
MACULA		

DIAGNOSIS:

_____

_____

_____

INVESTIGATIONS:

1. Lacrimal Patency:

	Patent	Regurgitation		Blocked
		Clear Fluid	Regurgitation	
RE				
LE				

2. IOP:

	By NCT	By Schiotz		
		5.5g	7.5g	10.0g
RE				
LE				

3. Blood Sugar: _____ mg% (RBS/FBS)
4. A-Scan:

   K_H

   K_v

   Axl:

   ACD:

   PCIOL:

TREATMENT GIVEN PREOPERATIVELY:

_____

_____

_____

_____

_

OPERATIVE PROCEDURE:

Surgery:Phacoemulsification : stop and chop /direct chop

Date:_____ Eye to be operated:Right/Left/Both

ANAESTHESIA: Peribulbar block/Topical

INCISION: Superior/Temporal/Supero temporal/Inferotemporal

OPERATIVE COMPLICATIONS: Present/Absent

If present,Specify-

_____

POST OPERATIVE COMPLICATIONS: Present/Absent

If present,Specify:

_____

Effective Phaco time (sec):

Cumulative Dissipated Energy (%):

Amount of aspiration fluid used (ml):

OPERATING SURGEON:

_____

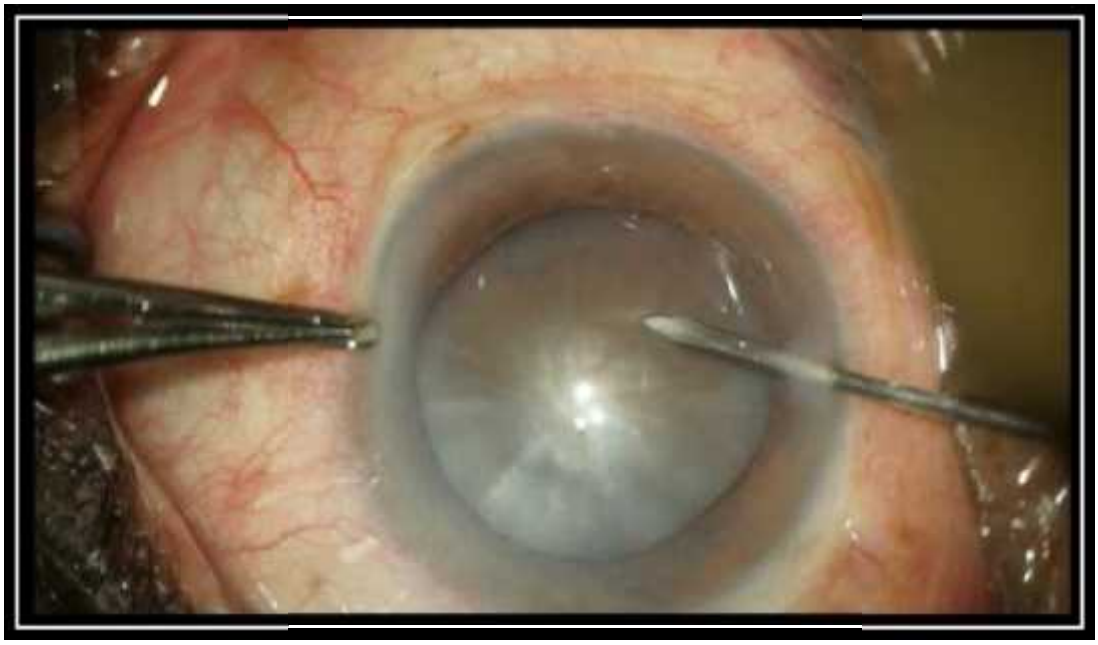
SURGEON'S SIGNATURE:

FOLLOW UP PLAN: POST OPERATIVELY-OPERATED EYE

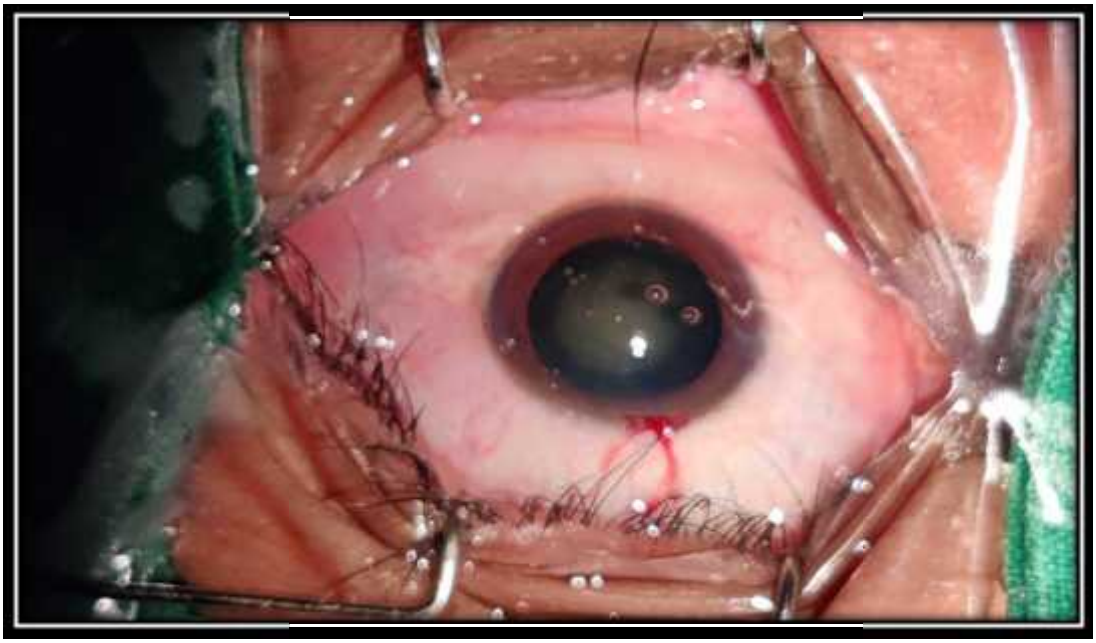
	1 DAY	1 WEEK	4 WEEKS
VISUAL ACUITY:			
DISTANT			
PINHOLE			
NEAR			
AIDED			
ANTERIOR SEGMENT:			
LIDS			
ADNEXA			
CONJUNCTIVA			
SCLERA			
CORNEA			
ANTERIOR CHAMBER			
IRIS			
PUPIL			
LENS			
FUNDUS EXAMINATION			
GLOW			
MEDIA			
DISC			
C:D RATIO			
BLOOD VESSELS			
BACKGROUND			
MACULA			
IOP(BY NCT)			
REFRACTION/RETINOSCOPY			

POST OPERATIVE COMPLICATIONS			
SUBCONJUNCTIVAL HEMORRHAGE			
GAPING OF INCISION			
CORNEAL EDEMA			
ZONULAR DEHISCENCE			
IRIS PROLAPSE			
NUCLEAR DROP			
PUPILLARY CAPTURE			
ANTERIOR CAPSULAR OPACIFICATION			
INTRA-OCULAR INFECTION			
IOL DISLOCATION			
IOL DECENTRATION			
CYSTOID MACULAR EDEMA			
SHALLOW AC/FLAT AC			
POSTERIOR CAPSULAR TEAR			
HYPHAEMA			
PSEUDOPHAKIC BULLOUS KERATOPATHY			
VITREOUS LOSS			
AFTER CATARACT			
GLAUCOMA			
IRIDODIALYSIS			
EXPULSIVECHOROIDAL HEMORRHAGE			

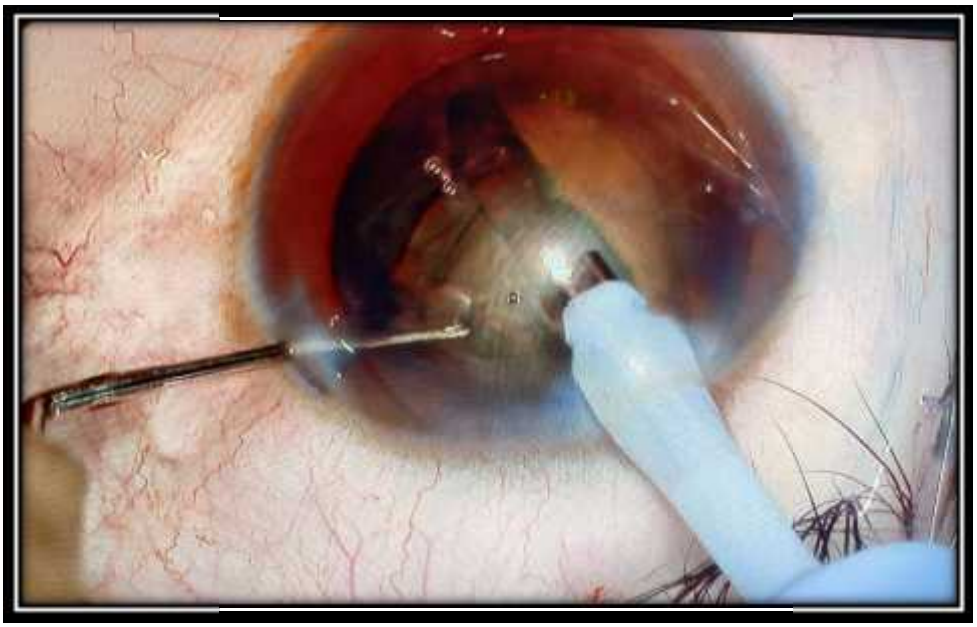
ANNEXURE IV -PHOTOGRAPHS



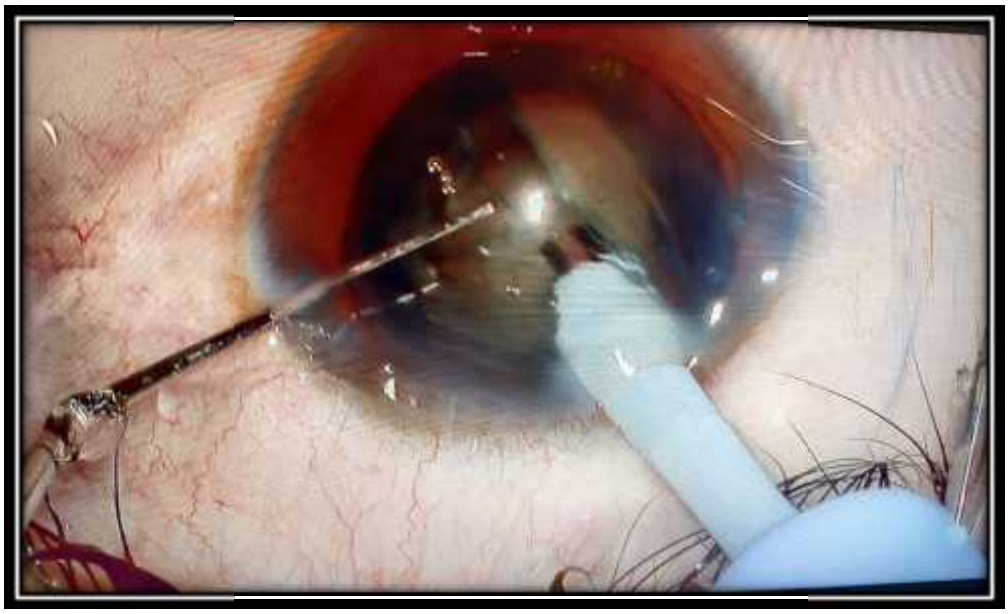
Photograph 1: Grade III Nuclear sclerosis



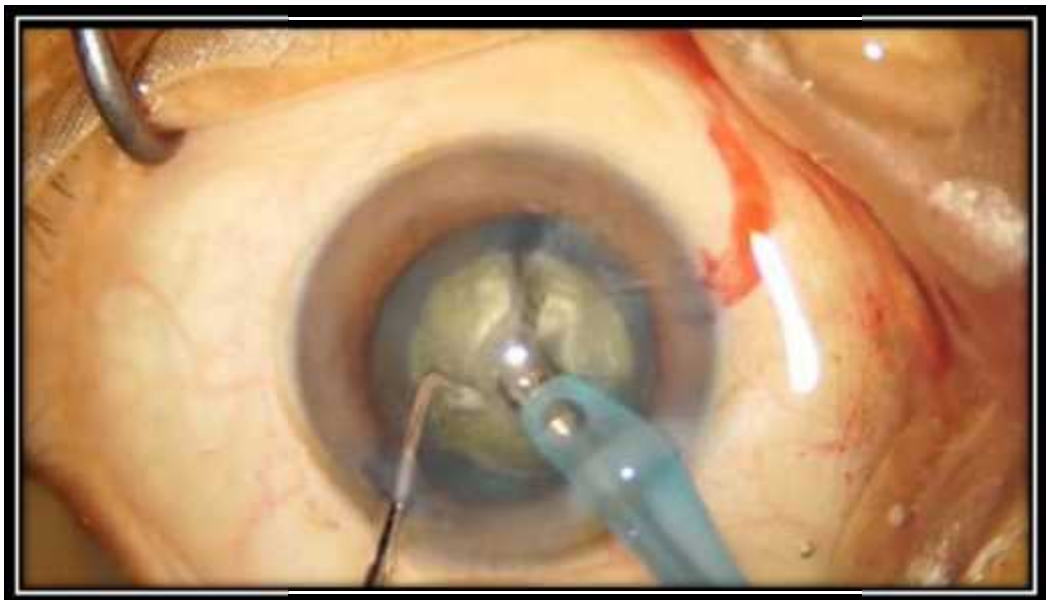
Photograph 2:After Capsulorrhexis



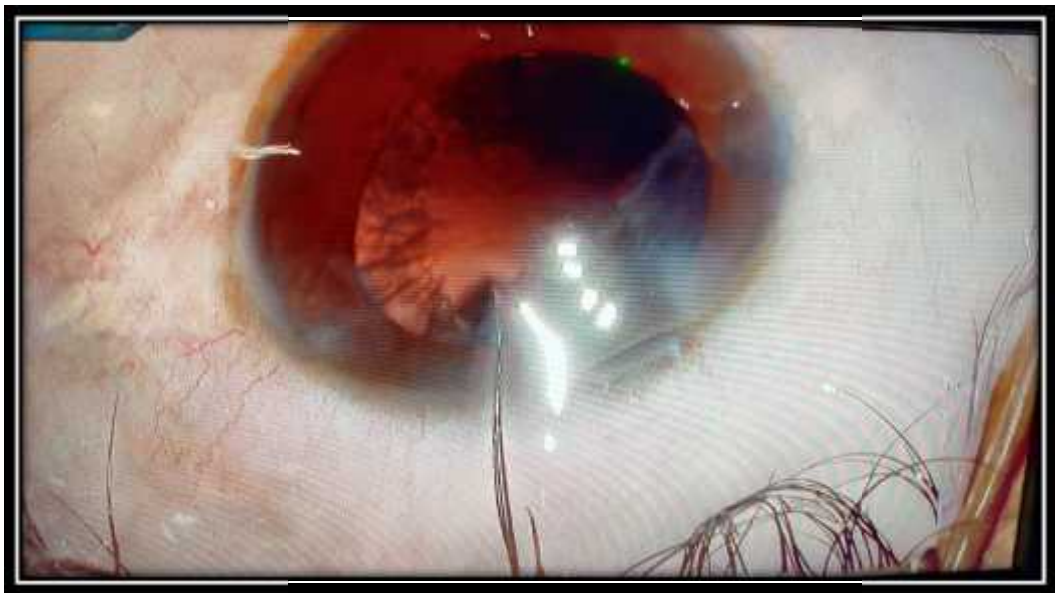
Photograph 3: Stopand chop technique: Sculpturing the trench



Photograph 4: Stopandchop technique :Splitting the nucleus into two halves

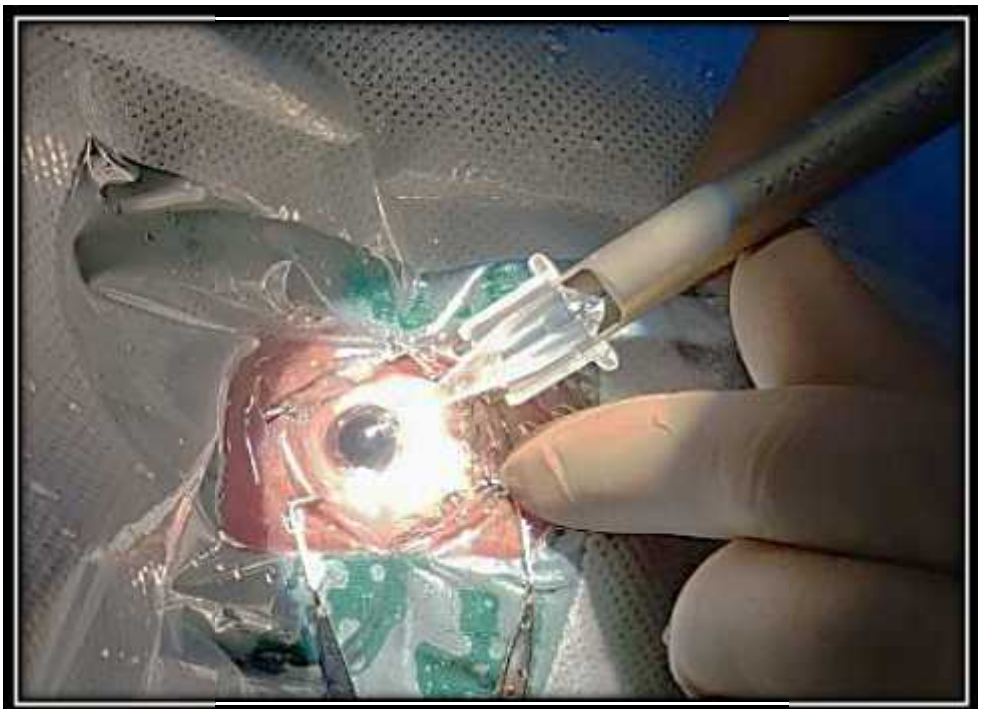


Photograph 5:Direct chop technique

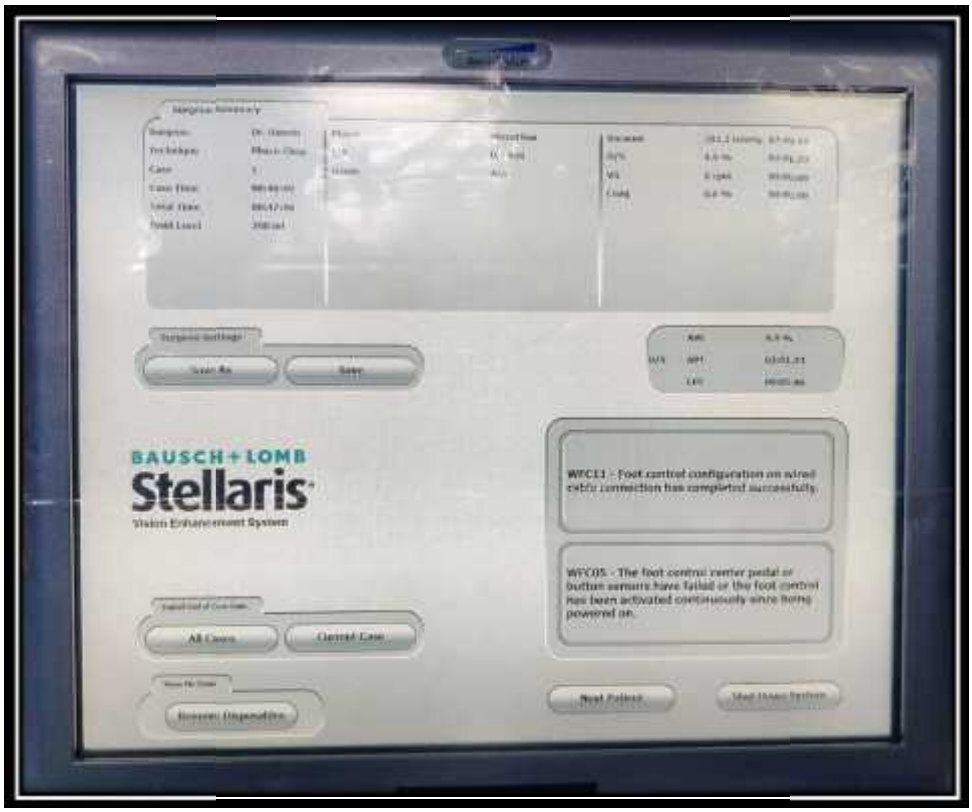


Photograph 6 :After complete nuclear emulsification

Photograph 7 :Loading foldable IOL into the cartridge



Photograph 8 : Injecting foldable IOL into the capsular bag



Photograph 9 :Intraoperative phaco parameters

Photograph 10:OT setup:Phaco in progress

ANNEXURE V

KEY TO MASTERCHART

CC	:	Cortical cataract
CF	:	Counting fingers
CFCF	:	Counting fingers close to face
DF	:	Descemet's Folds
F	:	Female
HMCF	:	Hand movements close to face
LE	:	Left eye
M	:	Male
MCE	:	Microcysticedema
NS	:	Nuclear sclerosis
PL	:	Perception of light
PR	:	Projection of rays
PSC	:	Posterior subscapular cataract
RE	:	Right eye
VA	:	Visual acuity

ANNEXURE VI

MASTERCHART (GROUP A)

Sl.no	Patient no:	Age	Gender	Eye	VA	Grading of cataract	Method	Effective phaco time	Phaco power(%)	Fluid(ml)	Post Op:Day 1	Findings	1 week	4 weeks-Va
1	953670	72	F	LE	6/36	LE grade III NS with PSC with CC	Direct Chop	3.61	6.7	150	6/12(P)		6/9	6/9
2	954220	71	M	RE	6/36	RE grade III NS	Direct Chop	4.54	6.1	180	6/18		6/12	6/12
3	954358	74	F	LE	CF-3 mtr	LE grade III NS with CC	Direct Chop	6.8	8.7	150	6/12		6/9	6/6(P)
4	959367	67	M	LE	CF-1 1/2 mtr	LE grade III-IV NS with CC	Direct Chop	11.56	8.1	175	6/24		6/18	6/12
5	954363	65	M	RE	CF-1 1/2 mtr	RE grade III NS with CC	Direct Chop	5.87	8.21	160	6/12		6/9	6/6(P)
6	954360	80	F	RE	HMCF	RE grade III NS with PSC with CC	Direct Chop	9.97	12.5	180	6/18		6/24	6/9(P)
7	955670	72	F	RE	6/18	RE grade III NS with PSC	Direct Chop	2.45	3.9	180	6/9		6/9	6/9
8	955657	59	F	LE	6/60	LE grade III NS with PSC	Direct Chop	4.46	6.4	160	6/24(P)		6/12	6/6
9	987858	60	M	RE	6/60	RE grade III NS with PSC	Direct Chop	7.6	10.1	160	6/18		6/12(P)	6/6(P)
10	987857	66	M	LE	6/24	LE grade III NS with CC	Direct Chop	15.4	15.8	200	6/18		6/18(P)	6/9
11	987857	70	F	LE	CF-2 mtr	LE grade III NS	Direct Chop	11.6	10.1	190	6/12		6/6(P)	6/6(P)
12	992766	72	M	RE	6/24	RE grade III NS with PSC	Direct Chop	4.05	6.74	180	6/12		6/9(P)	6/6(P)
13	992748	68	M	LE	CF- 1/2 mtr	LE grade III NS with CC	Direct Chop	3.78	5.87	190	6/24		6/24(P)	6/24
14	992917	75	F	RE	6/24	RE grade III NS with CC	Direct Chop	5.7	6.69	180	6/18		6/18	6/9(P)
15	992923	78	F	RE	6/18	RE grade III NS with PSC	Direct Chop	7.17	8.8	180	6/18		6/9(P)	6/9
16	3477971	58	M	LE	CF- 1/2 mtr	LE grade III NS	Direct Chop	3.92	5	170	6/9		6/6(P)	6/6
17	992921	56	M	LE	CF-2 mtr	LE grade III NS with PSC with CC	Direct Chop	4.2	5.17	190	6/9		6/9	6/6(P)
18	993591	52	M	LE	HMCF	LE senile mature cataract	Direct Chop	12.16	10.9	250	6/9		6/9	6/6
19	994270	59	M	RE	CF-2 1/2 meter	RE grade III NS with CC	Direct Chop	12.96	11	180	6/12		6/9	6/6
20	994359	76	M	LE	6/60	LE grade III NS with PSC	Direct Chop	5.7	7.93	190	6/12		6/9	6/6(P)
21	994356	70	M	LE	6/60	LE grade III NS with PSC with CC	Direct Chop	5.05	7.8	190	6/18		6/12	6/9
22	994353	76	M	RE	6/36	RE grade III NS with CC	Direct Chop	10.61	10.1	175	6/18		6/18	6/9(P)
23	994992	78	M	RE	6/60	RE grade III NS with PSC	Direct Chop	8.23	11.1	120	6/24	Cornea-DF+	6/18	6/9
24	996737	62	M	RE	CF - 1 mtr	RE grade III NS with PSC	Direct Chop	6.76	10.1	180	6/24		6/18	6/6(P)

25	996903	82	M	LE	PL+,PR-ACC	LE grade III NS with CC with PSC	Direct Chop	8.71	10.05	180	6/18		6/12	6/9
26	996789	75	F	LE	6/36(P)	LE grade III NS with PSC with CC	Direct Chop	13.52	12	180	6/24		6/24	6/9
27	997648	67	M	RE	6/24(P)	RE grade III NS with PSC	Direct Chop	6.41	8.23	190	6/6(P)		6/6(P)	6/6
28	959986	61	M	LE	6/36	RE grade III NS with PSC	Direct Chop	7.2	8.81	180	6/18		6/9(P)	6/6(P)
29	997474	70	M	LE	HMCF	LE grade IV NS with PSC	Direct Chop	8.8	10.2	200	6/24		6/12	6/9
30	998210	45	F	RE	CF-3 mtr	RE grade III NS with CC	Direct Chop	2.75	4.8	180	6/9		6/6(P)	6/6(P)
31	1001866	59	M	LE	PL+,PR-ACC	LE senile mature cataract	Direct Chop	9.4	11	200	HMCF	corneal edema	6/18	6/9(P)
32	998860	48	F	LE	HMCF	LE senile mature cataract	Direct Chop	6.5	10	180	6/18		6/12	6/6(P)
33	999875	60	F	LE	HMCF	RE senile mature cataract	Direct Chop	4.14	4.1	180	6/18(P)		6/8	6/9
34	999560	69	M	RE	HMCF	RE senile mature cataract	Direct Chop	8.3	9.1	180	6/36		6/12(P)	6/9
35	999646	65	M	LE	CF-1 1/2 mtr	LE grade III NS	Direct Chop	10.1	11.53	180	CF-1 1/2 mtr		6/18	6/12
36	949463	76	F	RE	HMCF	RE senile mature cataract	Direct Chop	9.5	11.1	190	6/18		6/12	6/9
37	999650	68	F	RE	CF-1 1/2 mtr	RE grade III NS with PSC	Direct Chop	10.7	12.9	180	6/24		6/12	6/9
38	1000150	70	M	LE	6/36(P)	LE grade III NS with PSC	Direct Chop	16.1	17.5	200	6/60	Cornea - MCE,DF	6/9(P)	6/6(P)
39	1000259	81	M	RE	6/36(P)	RE grade III NS with PSC	Direct Chop	11.52	7.1	200	6/36	Cornea-DF+	6/18	6/9(P)
40	1000186	66	F	RE	CF - 1 mtr	RE grade III NS with CC	Direct Chop	4.38	6	180	6/9		6/6(P)	6/6
41	949985	85	M	RE	6/36	RE grade III NS with CC	Direct Chop	3.92	7.4	180	6/12		6/9	6/6(P)
42	946715	73	M	LE	6/36(P)	LE grade III NS with CC	Direct Chop	5.83	8.1	180	6/12(P)		6/12(P)	6/6(P)
43	1002297	59	M	RE	6/24	RE grade III NS with CC	Direct Chop	3.17	5.8	150	6/12		6/9	6/6(P)
44	1002257	68	F	LE	CF - 1 mtr	LE grade III NS	Direct Chop	5.19	6.8	150	CF-3mtr		6/18	6/12
45	5628077	65	M	RE	CF-2 1/2 meter	RE grade III NS with PSC with CC	Direct Chop	4.9	6.4	190	6/12		6/12	6/6(P)
46	1001866	79	F	LE	PL+,PR-ACC	RE senile mature cataract	Direct Chop	3.67	6.2	150	6/18		6/12	6/9
47	1002766	49	M	LE	6/60	LE grade III NS with PSC	Direct Chop	8.7	5.1	125	6/36(P)		6/18	6/9
48	1002768	69	M	LE	CF-2 mtr	LE grade III NS	Direct Chop	5.56	9.3	160	6/24		6/12	6/6(P)

GROUP B

Sl.no	Patient no:	Age	Gender	Eye	VA	Grading of cataract	Method	Effective phaco time	Phaco power(%)	Fluid(ml)	Post Op:Day 1	Findings	1 week	4 weeks-Va
1	926754	68	F	LE	CF-1 1/2 mtr	LE senile mature cataract	Stop and Chop	4.05	6.80%	150	6/36		6/9(P)	6/9
2	927228	57	F	RE	CF- 1/2 mtr	RE senile mature cataract	Stop and Chop	2.74	4.7	120	6/9(P)		6/6(P)	6/6
3	928178	60	F	LE	CF- 1/2	LE grade III NS with PSC	Stop and Chop	23.84	7.1	250	CF-1 mtr	Corneal edema,DF+	6/12(P)	6/6
4	928179	51	M	RE	6/18	RE grade III NS with PSC	Stop and Chop	2.71	2.6	125	6/12(P)		6/12	6/9
5	930635	73	M	RE	6/24	RE grade III NS	Stop and Chop	14.52	13	250	6/24(P)	Corneal edema,MCE+	6/18(P)	6/18(P)
6	932075	70	M	LE	6/18(P)	LE grade III NS with PSC with CC	Stop and Chop	3.2	4.17	140	6/12		6/12	6/9
7	932076	68	F	LE	CF-1 1/2	LE senile mature cataract	Stop and Chop	16.57	17.6	280	CF-2 mtr	Corneal edema	6/18	6/9
8	932078	81	M	RE	PL+,PR-ACC	RE hyper mature cataract	Stop and Chop	15.5	15.9	275	CF-1 1/2	Corneal edema	6/36	6/9
9	932756	55	F	RE	CF - 1 mtr	RE senile mature cataract	Stop and Chop	10.17	13.6	200	6/24		6/9(P)	6/9
10	5206536	56	M	LE	CF-3 mtr	LE grade III NS	Stop and Chop	16.45	14.7	250	6/9		6/9	6/6(P)
11	5216132	63	F	RE	6/60	RE grade III NS with PSC	Stop and Chop	17.44	15.1	250	6/18		6/18	6/9
12	5215849	75	F	LE	CF-2 mtr	LE grade III NS with PSC with CC	Stop and Chop	12.61	11.1	170	6/12(P)		6/12(P)	6/6(P)
13	3057733	60	F	LE	CF- 1/2 mtr	LE grade III NS with CC	Stop and Chop	4.05	6.8	120	6/12		6/12	6/6(P)
14	928179	68	M	RE	CFCF	RE grade III NS	Stop and Chop	7.67	10.3	180	6/12(P)		6/9	6/6(P)
15	3603785	59	F	LE	CF-1 1/2 mtr	LE grade III NS with PSC	Stop and Chop	3.23	5.6	100	6/24		6/12	6/9
16	942003	68	M	LE	6/24	LE grade III NS with PSC	Stop and Chop	5.74	8.3	120	6/18		6/12	6/6(P)
17	942328	51	F	RE	6/60	RE grade III NS with PSC	Stop and Chop	8.23	11.1	120	6/18		6/6	6/6
18	522777	73	M	LE	CFCF	LE senile mature cataract	Stop and Chop	7.94	7.5	150	6/9(P)		6/9	6/6
19	942452	65	F	RE	CF-2 mtr	RE grade III NS with CC	Stop and Chop	3.17	5.8	120	6/12(P)		6/9	6/6(P)
20	942983	65	M	RE	CF-1 1/2 mtr	RE grade III NS with PSC	Stop and Chop	5.83	8.1	100	6/9		6/9	6/6
21	4525406	72	M	RE	CF-2 mtr	RE grade III NS	Stop and Chop	20.97	11.9	200	6/24	Corneal edema	6/18	6/9
22	5164816	67	M	RE	CF- 1/2 mtr	RE grade III NS with PSC	Stop and Chop	11.55	7.1	230	6/6		6/6	6/6
23	937636	68	M	RE	6/60	RE grade III NS with CC	Stop and Chop	13.96	12	240	6/6(P)		6/6(P)	6/6(P)
24	939724	69	M	RE	CF- 1/2 mtr	RE grade III NS with PSC	Stop and Chop	7.17	8.8	200	6/9		6/9	6/6(P)

25	939726	51	F	RE	CF- 1/2 mtr	RE grade III NS with PSC	Stop and Chop	8.73	12	240	6/9		6/9	6/9
26	944510	60	F	RE	HMCF	Right eye hyper mature cataract	Stop and Chop	19.9	13	270	6/60	Corneal edema	6/12	6/12
27	5159064	66	M	LE	CF-1 1/2 mtr	LE grade III NS with PSC	Stop and Chop	8.12	9	150	6/12		6/12	6/9
28	946565	69	F	RE	6/60	RE grade III NS with CC	Stop and Chop	4.73	5.4	150	6/9		6/9	6/6(P)
29	946716	51	F	RE	6/60	RE grade III NS with PSC	Stop and Chop	6.1	8.2	130	6/12		6/9	6/6(P)
30	947823	59	F	LE	HMCF	LE senile mature cataract	Stop and Chop	3.31	6.3	130	6/9		6/9	6/6(P)
31	948846	65	F	LE	CF - 1 mtr	LE grade III NS with PSC with CC	Stop and Chop	1.18	3	80	6/9		6/9	6/6
32	24-May	65	F	LE	6/36	LE grade III NS with CC	Stop and Chop	4.44	6	180	CFCF	Corneal edema	6/24(P)	6/9
33	949456	75	M	RE	6/60	RE grade III NS with PSC	Stop and Chop	7.17	5	125	6/9(P)		6/9(P)	6/9
34	949312	80	M	LE	CF-3 mtr	LE grade III NS with PSC	Stop and Chop	1.42	3.6	110	6/12		6/9(P)	6/9
35	950176	52	M	RE	CF-2 mtr	RE grade III NS with PSC	Stop and Chop	2.04	3	125	6/18		6/9	6/6(P)
36	950754	52	F	RE	HMCF	RE hyper mature cataract	Stop and Chop	12.78	11.5	235	6/9(P)		6/9	6/9
37	1363171	68	F	RE	CF-3 mtr	RE grade III NS with CC	Stop and Chop	5.46	10.1	120	6/18		6/12	6/6(P)
38	5280836	62	F	LE	CFCF	LE senile mature cataract	Stop and Chop	9.1	9.9	180	6/12		6/9	6/9
39	951550	68	F	LE	6/18(P)	LE grade III NS with PSC	Stop and Chop	5.38	6.5	150	6/18(P)		6/18(P)	6/9
40	951557	77	F	LE	6/18(P)	LE grade III NS with CC	Stop and Chop	10.9	10.6	200	6/24		6/12	6/9(P)
41	951369	54	F	RE	6/18(P)	RE grade III NS with PSC	Stop and Chop	4.05	6.8	140	6/9		6/9	6/6(P)
42	951392	52	F	RE	HMCF	RE grade III NS with CC	Stop and Chop	11.2	12.4	180	6/36(P)	Cornea-DF+,MCE	6/36(P)	6/12
43	951556	53	F	RE	CF - 1 mtr	RE grade III NS with CC	Stop and Chop	14.3	15.6	185	6/9(P)		6/9	6/9
44	952680	56	M	LE	6/36(P)	LE grade III NS with PSC	Stop and Chop	6.4	8	180	6/24		6/9(P)	6/9(P)
45	952893	60	F	LE	HMCF	LE senile mature cataract	Stop and Chop	11.6	10.1	200	6/24		6/9	6/9
46	952714	50	F	RE	CFCF	RE grade III NS	Stop and Chop	4.23	6.6	160	6/9(P)		6/9(P)	6/6(P)
47	952794	67	M	LE	6/18(P)	LE grade III NS with PSC	Stop and Chop	6.74	9.3	200	6/18		6/12(P)	6/9
48	953608	58	M	RE	CFCF	RE grade III NS	Stop and Chop	7.6	9.3	190	6/12		6/9	6/6(P)