# EVALUATION OF PHACOEMULSIFICATION TECHNIQUE FOR CATARACT SURGERY IN DOG

*A Thesis*
*submitted to the*
*West Bengal University of Animal and Fishery Sciences*
*in partial fulfillment of the requirements for the Degree of*

**DOCTOR OF PHILOSOPHY**
**in**
**VETERINARY SURGERY AND RADIOLOGY**

**By**

*Sarbani Hazra*
*M.V.Sc.*



**DEPARTMENT OF VETERINARY SURGERY AND RADIOLOGY**
**FACULTY OF VETERINARY AND ANIMAL SCIENCES**
**WEST BENGAL UNIVERSITY OF ANIMAL AND FISHERY SCIENCES**
**37 & 68 KSHUDIRAM BOSE SARANI, KOLKATA- 700 037**
**2006**

# Dedicated to Almighty

West Bengal University of Animal & Fishery Sciences
*DEPARTMENT OF VETERINARY SURGERY & RADIOLOGY*
*FACULTY OF VETERINARY & ANIMAL SCIENCES*

37 & 68, KSHUDIRAM BOSE SARANI,
KOLKATA - 700 037
Phone No. 556-9234
Fax No. 91-033-557-1986
Gram - VETUNIV

*Ref No*.................................. *Date*. : 11 - 09 - 2006

**Prof. (Dr.) Dipak kumar De**
**M.V.Sc., Ph.D.**

# *Certificate*

*This is to certify that the work embodied in this thesis entitled* ***"Evaluation of Phacoemulsification Technique for Cataract Surgery in Dog"*** *submitted by* ***Dr. Sarbani Hazra*** *in partial fulfillment of the requirements for the* ***Degree of Doctor of Philosophy*** *in* ***Veterinary Surgery and Radiology*** *of* ***West Bengal University of Animal and Fishery Sciences,*** *is the faithful and bonafide research work carried out under my personal supervision and guidance. The results of the investigation reported in the thesis have not so far been submitted for any other Degree and Diploma. The assistance and help received during the course of investigation have been duly acknowledged.*

Dated, The 11th Sept., 2006
Kolkata - 700 037

Dipak kumar De
Prof. (Dr.) Dipak kumar De
Chairman,
Advisory Committee

# CERTIFICATE OF APPROVAL BY MEMBERS OF THE ADVISORY COMMITTEE AND EXTERNAL EXAMINERS

## Certificate

Certified that the thesis entitled "**Evaluation of Phacoemulsification Technique for Cataract Surgery in Dog**" submitted by Dr. Sarbani Hazra, in partial fulfillment for the degree of Doctor of Philosophy in Veterinary Surgery and Radiology of West Bengal University of Animal and Fishery Sciences, Kolkata embodies the original work done by the candidate. The candidate has carried out his/her work sincerely and methodically.

It is therefore approved on 11th December, 2006, for award of the Degree of Doctor of Philosophy in Veterinary Surgery and Radiology of this institute.

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| 2. PROF. A.P. SINGH. | External Examiner | [signature] 11/12/06 |
| 3. Dr. Debaki Ghosh | Member Advisory Committee | [signature] 11/12/06 |
| 4. Dr. Subhasis Batabyal | Member Advisory Committee | [signature] |
| 5. Dr. Biswarup Roy | Member Advisory Committee | [signature] 11/12/06. |

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Sarbani Hazra.
(SARBANI HAZRA)

# ABBREVIATIONS

| | |
|---|---|
| @ | : At the rate of |
| ARVO | : Association for Research in Vision and Ophthalmology |
| BSS | : Balanced Salt Solution. |
| CCC | : Continuous curvilinear capsulorhexis. |
| Cm | : Centimeter |
| CT | : Computed Tomography |
| ECCE | : Extra Capsular Cataract Extraction |
| ERG | : Electroretinography. |
| *et al* | : et alli, and others . |
| Fig . | : Figure. |
| GSH | : Glutathione |
| ICCE | : Intra Capsular Cataract Extraction |
| *i.e.* | : That is |
| IOL | : Intraocular Lens |
| IOP | : Intraocular Pressure. |
| MDA | : Malondialdehyde. |
| mg | : Milligram |
| ml | : Millilitre |
| MVR | : Microvitreoretinal |
| NSAIDS | : Non Steroidal Anti-inflammatory Drugs |

| | |
|---|---|
| PCO | : Posterior Capsular Opacification. |
| PMMA | : Polymethylmethacrylate. |
| PRA | : Progressive retinal atrophy. |
| STZ | : Streptozotocin. |
| USG | : Ultrasonography |

# CONTENTS

# List of Figures

16. Insertion of intraocular lens.

17. The intraocular lens being positioned by dialing the trailing haptic using a Sinskey Hook.

18. The corneal incision being closed with 10-0 mono filament nylon.

19. Self inflected trauma was prevented by giving E-Collars postoperatvely.

20. Normal eye of dog prior to induction of cataract.

21. Clinical evidence of initial signs of cataract development.

22. Progressive stage of cataract development.

23. Eye of dog showing complete cataract formation after induction.

24. Normal lens of rat showing well developed fibrocollagenous capsule containing lens protein; with parallel bar arrangements without cellular infiltration.

25. Cataractous lens of rat showing well developed fibro collagenous capsule with a focal area showing infiltration of a few lymphocytes.

26. Normal lens of dog showing intact capsular membrane with lamellar pattern of the lens protein which appeared structure homogeneous and eosinophilic.

27. Cataractous lens of dog showing intact thick capsular membrane with lamellar pattern of the lens protein which appeared fragmented and eosinophilic.

28. Anterior uveitis observed after one week of operation.

29. Anterior uveitis is less severe after two weeks of treatment.

30. Anterior uveitis almost cured at third week postoperatively.

# INTRODUCTION

# Introduction

Cataract literally means to "break down", which refers to the disruption of the normal lamellar architectural arrangements of the lens fibers or its capsule, resulting in loss of transparency of the crystalline lens. This opacification of the lens of the eye is one of the leading causes of blindness worldwide and accounts for nearly 42% of the all blindness (Kyselovaz *et al.,* 2004).

Much study on the incidence and prevalence of cataract in the canine population has not been taken up. However, a study on prevalence of canine cataract was carried out by Williams *et al.,* (2004), to fill this gap in veterinary ophthalmic research. Results of this study depict that all dogs over 13.5 years were affected by some degree of lens opacity. In fact cataracts in dog parallel those in man. Considering the larger number of recognized breeds in dog, the number of inherited cataracts in the dog probably exceeds those in man (Gelatt and Mackay, 2005). The epidemiological data of cataract in canine population in India is yet to be explored, but a number of cases are encountered regularly. A majority of the cases are left untreated due to lack of adequate facilities and owner consciousness.

Although multiple mechanisms have been implicated in the development of cataract, there is a paucity of information on the biochemistry and morphology of the normal as well as cataractous canine lens. It has been opined that although the inciting cause may differ for each type of cataract, most of the biochemical and morphological events appear similar (Gelatt, 1985). Events of cataractogenesis of inherited congenital cataract in the Miniature Schnauzer have been investigated to some extent (Daniel *et al.,* 1984; Gelatt *et al.,* 1982; Monaco *et al.,* 1984 and Samuelson, 1987). Understanding the biochemical events of cataractogenesis could help to design a highly required pharmacological intervention that will maintain the transparency of the lens.

It has been estimated that a delay in cataract formation of about 10 years would reduce the prevalence of visually disabling cataract by 45% (Kupfer, 1984); such a delay would enhance the quality of life. As the understanding of the cellular and molecular changes associated with cataract formation becomes refined, the possibility increases of delaying its onset. Although the benefits of cataract prevention are obvious, the likelihood of achieving appears difficult; hence the challenges of cataract research are worth taking up.

The importance of appropriate animal models of the disease are therefore realized, for further studies on cataract pathogenesis and studies on anticataract or cataract preventing drugs.

Surgery still remains the effective treatment of cataract. By convention the terms extracapsular cataract extraction refers to an operation in which the lens, nucleus and cortex, excepting the posterior capsules are removed through a limbal incision, of a length about one half the circumference of the cornea. In veterinary ophthalmology, this was the method of choice for a long time (Startup, 1967; Rooks *et al.*, 1985; Paulsen *et al.*, 1986). The main disadvantages of this method are the size of the incision and the need of progression of cataract, which in turn leads to phacolytic uveitis development and absence of visible tapetal reflection, making it difficult to visualize the anterior capsule. Other disadvantages encountered with extracapsular cataract extraction are prolonged duration of surgery and post operative healing (Hazra and Samanta, 2000).

Introduction of phacoemulsification by Kelman (1967), has dramatically improved the success rate of cataract surgery. Recent studies revealed that phacoemulsification yields the highest rates of cataract extraction in dogs (Gelatt, 1991). In this procedure the lens is ultrasonically fragmented and aspirated through an incision about 3 mm with the advantages of smaller incision, less operating time, lesser astigmatism, lesser complications and better recovery (Gelatt, 1991). One of the main limitations of phacoemulsification, is the fact that it is one of the most difficult intra-ocular techniques to master. Since the learning curve of phacoemulsification is long, wet lab training is considered essential (Vinicus and Fabiott, 2003).

The phacoemulsification procedure requires relatively complex co-ordination of hands and feet and the margins for inaccurate manipulations are small. The success of the operation is highly related to the maintenance of an intact capsular bag. Despite careful training, residents are reported to have an incidence of 55 to 20% of capsular ruptures during their first 200 cases (Cruz *et al.*, 1992; Tarbet *et al.*, 1995; Yang *et al.*, 1995; Robin *et al.*, 1997). Similar figures have been reported for experienced surgeons learning phacoemulsification (Seward *et al.*, 1993; Thomas *et al.*, 1994).

Reports of a study on the incidence of operative and post operative complications during phacoemulsification in 244 dogs suggests posterior capsular disruption in 14% of the eyes (Johnston and Ward, 2005). In a report on the current status of phacoemulsification training in US, it was stated that the impending decline in quality of phacoemulsification training in residencies can be prevented if creative and innovative solutions were sought, one such solution suggested was use of improved animal eye practice (Smith, 2005).

A number of experimental models have been designed to enhance the surgical skills. Cataract has been induced in enucleated post mortem pigs eye (Van.Vreeswijk and Pameyer, 1998), post mortem goats eye (Dada and Sindu, 2000; Sudan *et al.,* 2002). Human post mortem eye have also been used for on hand practice of phacoemulsification (Borirak-Chanyavat *et al.,* 1995; Liu *et al.,* 2001). Use of plastic eye models for surgical training has been reported (Maloney *et al.,* 1988). Special devices have also been developed for teaching ocular surgical procedures (Porrello *et al.,* 1999). One of the latest aids to reduce the learning curve is the computer simulated phacoemulsification (Laurell *et al.,* 2004).

All experimental models mentioned so far may serve as satisfactory models for practicing phacoemulsification, but will not simulate similar conditions like working on live eye. Live models of cataract have been created but mostly in small laboratory animals. Live models of cataract in dog have also been reported (Martin, 1975; Martin and Chambreau, 1982), but the cataracts developed in these studies were of transient nature.

A study on lens and cataract research of the 20$^{th}$ century was analyzed, from a clinical, biological, and mainly biochemical point of view. It was pointed out that the research efforts with remarkable financial inputs, along with large number of scientists involved world wide does not correspond to the results obtained. A reason pertaining to the situation could be the missing co-operation between clinicians, epidemiologists and basic lens researchers, ignorance of the basic researchers regarding clinical problems could be the reason for the errors and misunderstandings (Hockwin *et al.,* 2002). On the other hand on basis of the success of the cataract surgery, most clinicians have developed the opinion that lens and cataract research is no longer necessary to overcome cataract blindness, Such outlook is not justified considering the fact that millions of people are blinded by cataract, Moreover many people in developing countries cannot bear the expense of surgery. The numbers may differ but the situation is almost similar in veterinary cataract research too.

Hence, it would be justified if research in cataract therapeutics could run parallel with improvisation of techniques in cataract surgery to provide a complete solution. Keeping this goal in mind, this study on canine cataract was undertaken with following objectives.

1. To create a live model of cataract in dog.
2. To standardize the anaesthetic regimen for performing phacoemulsification in dog.
3. To evaluate the phaco-chop technique for cataract removal in dog.
4. To study the post-operative complications and recovery of vision.

# REVIEW OF LITERATURE

## Review of Literature

### Incidence and prevalence of cataract

Cataract, the opacification of the lens accounts for approximately 42% of all blindness in the human population (Kyselova *et al.,* 2004), over 20 million people are blinded by cataract, it has been reported from large cross sectional population-based studies that almost 75% of people over the age 75 have sight impairing opacification (Klein *et al.,* 1998)

There is paucity of literature in veterinary ophthalmology research regarding population based studies on canine cataract. Preliminary results of a cross-sectional study on prevalence of canine cataract reveals that prevalence of cataract in the general canine population increases with age, all dogs above 13.5years of age were affected with some degree of lens opacity (Williams *et al.,* 2004)

The study of cataract incidence in a population of 39,229 dogs over a period of four decades (1964-2003), showed that prevalence of cataract formation in this patient population increased by 225% over the years (Gelatt and Mackay, 2005). In this study the breeds with highest prevalence include, Smooth Fox Terrier (11.70%), Havanese (11.57%), Bichon Frise (11.45%), BostonTerrier(11.11%), Miniature Poodle (10.79%), Silky Terrier (10.29%) and Toy Poodle (10.21%), it was suggested that cataract formation is one of the most prevalent eye diseases in the dog ,total age related cataract prevalence in dogs is similar to that in man (Gelatt and Mackay, 2005).

Diabetes mellitus is one of the most common endrocrinopathies in the dog and cat, yet diabetic cataract primarily affects the canine species, and rarely observed in cat. Almost every dog with diabetes will develop cataract with or without insulin treatment (Bagley and Lavach, 1994). On the contrary no significant relation between the incidence of cataracts and the correspondent level of hyperglycemia in the canine and feline species could be established (Salgado *et al.,* 2000)

Prevalence of presumed inherited eye diseases noncongenital cataract and progressive retinal atrophy in the Entlebucher Mountain dog have been studied for systemic environmental influences and the additive genetic variation. The additive genetic correlation between noncongenital cataract and progressive retinal atrophy was moderately positive (Iieitmann *et al.*, 2005).

Inherited cataract in Bichon Frise was determined, dogs between 2 and 8 years of age were most frequently affected, and initial cataract involvement affected equally the anterior and posterior cortices, immature cataracts occurred more in younger dogs, and hypermature cataracts were frequently diagnosed in older dogs (Gelatt *et al.*, 2003).

**Studies on anticataract therapeutics**

Cataract in the human population accounts for a major cause of blindness. In the United States over 1.3 million cataract operations are performed annually. In developing countries there are not sufficient numbers of surgeons to perform cataract operations. It has been estimated that a delay in cataract formation of about 10 years would reduce the prevalence of visually disabling cataract by about 45 %( Kufer, 1984).

In the U.K, half the patients put on waiting lists for operation will die before getting surgery (Minassian *et al.*, 2000). Keeping in view the present situation there is requirement for a biochemical solution or pharmacological intervention that will maintain the transparency of the lens, so despite medical progress in surgical procedures, alternative approaches to prevent or at least delay the formation of cataract are desperately needed.

Orgotein (Palosein) with marked superoxide dismutase activity used intracamerally to treat senile cataract in dogs failed to show subjective improvements in dogs visual behaviour (Brainard *et al.*, 1982), on the contrary fresh intact lenses were treated with H2O2 and incubated with and without superoxide dismutase, results showed that lenses overexpressing SOD1 remained clear after H2O2 treatment, indicating the overexpression of SOD1 prevents H2O2 induced oxidative damage (Lin *et al.*, 2005).

Amongst the various mechanisms of cataractogenesis lipid peroxidation is one of the important causative and pathogenic factor for cataract formation (Babizhayev, 2005). He determined the pharmacokinetic parameters and the time course of N-acetylcarnosine and L-carnosine related product in the eye. Following a single dosage of topical ocular administration of the peptide, he concluded that the ophthalmic NAC drug shows promise in the treatment of a range of ophthalmic disorders that have a component of oxidative stress in their pathogenesis.

Varma *et al.* (2005) examined the feasibility of inhibiting cataract formation by treatment with pyruvate, which is effective reactive species scavenger, in addition, pyruvate stimulates tissue metabolism, which is depressed with the onset of cataract formation. The findings of their study emphasized the clinical usefulness of inhibiting treatment with antioxidants and metabolic agonists even when the lens changes are detected at the time of diabetes diagnosis.

Prophylactic intake of antioxidants is beneficial in delaying the onset of ageing manifestations such as cataract, in order to establish whether such supplementation will also be effective if the pathophysiological process has already set in, a study was conducted by adding pyruvate to the culture medium after lenses had sustained a 50% damage, and results showed it was significantly effective in preventing progress. Glutathione levels were also higher in the pyruvate group (Varma *et al.*, 2006).

The activities of the protective enzymes, superoxide dismutase, catalase and glutathione peroxidase were measured in the cortical and nuclear sections of the human cataractous lens as well in calf, it was suggested that inactivation of these enzymes may result in elevation of the H2O2 and O2 levels in the lens, which may be responsible for oxidative modification of the lens protein (Fecondo and Augusteyn, 1983).

The lens pathology in the galactosemic model is similar to that observed in diabetes, which makes galactosemic a rapid and more human model for diabetes. It has been reported in rats, galactosemia causes changes in protein kinase Cγ (PKCγ) and gap junction activity, the resulting changes in lens gap junctions contribute to cataract formation.

Aldose reductase inhibitors have been used as a preventive treatment, currently used aldose reductase inhibitors are not very water soluble and many are not adequately transported to the eye. Takemoto *et al.* (2004) tested a new class of aldose reductase inhibitors HAR-1in dog to determine if it can prevent the changes in lens PKCγ and can normalize gap junction activity, Results indicated that HAR-1 was not toxic to dogs at early periods and could be used for prevention of cataract in dogs.

The water extract of Aralia elata (Aralia extract) has been used for treating diabetes mellitus, in Korean traditional medicine. Young Shin Chung et al. (2005) investigated the aldose reductase inhibiting activity, antioxidant activity and anticataract capacity of Aralia extract using various experimental systems. Homogenized rat lens had been used for in vitro study, the study showed that Aralia extract inhibits aldose reductase and acts in vitro as an antioxidant which suggests that these activities have a preventive effect on cataractogenesis and in vivo in STZ induced diabetes in rats.

Hiraoka and Clark (1995), observed that panthethine, inhibited lens opacification during cataract formation in the selenite model, even when panthethine was injected several hours after the administraton of selenite, opacification was inhibited. Although the inhibitory effect of pantethine was statistically significant when administered during the earliest stage of opacification in the selenite model for cataract.

The use of non steroidal anti-inflammatory drug has been evaluated for anticataract action in the prevention for cataracts induced by selenite. Treatment with naproxen resulted in showing a significant preventive effect. Observations of this study also suggested that naproxen acts as an anti-oxidant (Gupta and Joshi, 1994). Results of potential protective effects of NSAIDS/ASA in human lens epithelial cells showed a relatively small therapeutic window (Petersen *et al.*, 2005).

Investigations were carried out to see if Resveratrol can prevent sodium selenite induced experimental cataract in rat. Encapsulated lenses and erythrocytes were analysed for reduced glutathione (GSH) and Malondialdehyde (MDA) a marker of lipid peroxidation. Resveratrol suppressed selenite induced oxidative stress and cataract formation in rats, this protective effect was supported by higher GSH and lower MDA in lens and erythrocytes (Doganay *et al.*, 2006).

Iodide has been since long time has been used against different eye related diseases including cataract. Muranov *et al.* (2004) studied the protective effect of iodide on the selenite model of cataract and observed that there was time dependent protective influence of iodide against selenite cataract development. The anticataract effect of iodide could be based on direct or indirect antioxidant mechanisms.

The antioxidant action of vitamin-E has also shown to prevent cataract formation in methylprednisolone (MP)-induced cataract model, by protecting against oxidative damage and loss of membrane function (Ohta *et al.*, 1996).

H2O2 stress has shown to produce cataract in cultured rat lens, the Alcon glutathione peroxidase type mimic, Al-3823, completely eliminates almost all the H2O2 induced effects and lens remains transparent. The fact suggests that such compounds may prevent cataract caused by oxidative stress under physiological conditions (Spector *et al.*, 1993).

Calpain inhibitors for cataract prevention have long been under study. The amount of calpain inhibitor uptake by lens of rats, was detected, after SJA6017, was administered daily using intraperitoneal injection at 100mg/kg body wt/day for 4 days. Systemic SJA6017 ameliorated in vivo selenite cataract formation, (Tamada *et al.*, 2001; Biswas, 2004). Recent studies suggests that proteases whose activation requires the presence of Ca2+ and elevated levels of Ca2+ is a condition strongly associated with cataract, calpain 2 appears to be the major calpain involved in animal cataractogenesis, the studies on role played by calpain 2 in cataractogenesis has been reviewed (Biswas *et al.*, 2005).

Antioxidant protection in cataract development using green leaves, Camellia Senensis was studied, lenses were incubated with GTL extract and the enzyme activity of superoxide dismutase, catalase and glutathione were evaluated. Results showed significant anticataract potential (Gupta *et al.*, 2002), similar results were observed with OcimumSanctum (Gupta, 2005), Cumin and Tumeric (Suyanarayan, 2005).

**Surgical treatment of cataract**

Cataract is one of the leading causes of unilateral and more often bilateral blindness in dogs. The only effective mean of its treatment is surgery – extraction of diseased lens (Dziezyc, 1990) and its replacement by an artificial intraocular lens (IOL – “intraocular lens”). The opinions on cataract surgery have been changing continually with advancement of the procedure. The success rate of cataract surgery has risen significantly during last decades, especially due to development of more precise microsurgical techniques and with introduction of phacoemulsification (Boldy, 1988; Dziezyc, 1990) and IOL implantation.

**History of cataract surgery**

"Cataract surgery" was initiated in ancient India as early as 2000 years B.C.; at that time the only attempt was to restore vision by iatrogenic posterior luxation of cataractous lens – reclination.

In 1745 Daniel performed the first extracapsular cataract extraction (ECCE). In 1753 Sharp performed the first intracapsular cataract extraction (ICCE) by expression of the nucleus using a thumb (Kecova and Necas, 2004). During the $17^{th}$, $19^{th}$ and the beginning of $20^{th}$ century, the most popular method of cataract extraction was ICCE (different methods of mechanical zonulolysis). After the $2^{nd}$ World War, the ECCE became more popular with development of better operating microscopes. In 1949 Harold Ridley implanted first posterior chamber IOL in a 60-year-old woman after previous anterior chamber inflammation following "primitive" ECCE (without irrigation/aspiration of remaining cortical material), this method was again replaced by intracapsular extraction (Kecova and Necas, 2004). Barraquer in 1957, carried out the first ICCE using enzymatic zonulolysis (Barraquer, 1958) and in 1961 first cryoextraction was done by Drawicz (Kecova and Necas, 2004). In 1970s, with improved irrigation/aspiration devices and capsulotomy techniques, surgeons again returned to ECCE (now with complete removal of remaining cortical material). With the development of ultrasound machines creating low frequency ultrasound waves, in 1967 Kelman carried out first so called "phacoemulsification" of the lens, or ECCE using phacoemulsification (Kelman, 1967). Removal of the nucleus through a small incision pushed research in development of new machines as well as artificial IOLs. Since then the progress was in introduction of viscoelastics (protection of intraocular structures, facilitation of manipulation in the eye) (Craig, 1990; Artola, 1993), development of more sophisticated technical equipment, miniaturization of the instruments and in improvement of IOL material (Linebarger *et al.*, 1999).

The first cataract extraction in dog was performed by Moller in 1886 and later by Berlin in 1887(Gelatt and Gelatt, 2001). Muller and Glass in1926 and Ratigan in1928 reported good results with the discission technique in young animals. Despite caution from Fromston in 1952, that cataract surgery was fraught with difficulties and is speculative, the evolution of cataract surgery continued in small animal. In 1953 Margrane described aspiration of canine cataracts (Kecova and Nicas, 2004).

The ICCE method was initially used – mechanical or enzymatic zonulolysis with chymotrypsin (Startup, 1967 b; Barrie *et al.*, 1982). The advantage of this method consisted in removing lens with the intact capsule, without exposing any of its material within the eye. The disadvantages are the prolapse of the vitreous with risk of retinal detachment (Dziezyc, 1990) and the size of incision (approximately $190^{o}$ of limbal circumference, or 20-22 mm) resulting in large extent of astigmatism and marked inflammatory and fibrin reaction with subsequent complications. The next method, in veterinary ophthalmology used for a long time, was ECCE (Startup, 1967 a; Rooks *et al.*, 1985; Paulsen *et al.*, 1986). The main disadvantages are the size of incision and the need of progression of cataract (surgery at the time of mature cataract). With the progression of cataract, the phacolytic uveitis develops and with no visible tapetal reflection, it can be quite difficult to visualize the anterior capsule during capsulotomy.

Presently in veterinary ophthalmology the method of choice for cataract extraction in most cases is phacoemulsification, or removal of lens material through small incision with fragmentation, emulsification and aspiration (Miller *et al.*, 1987; Gaiddon *et al.*, 1988; Dziezyc, 1990; Nasisse *et al.*, 1990; Davidson *et al.*, 1991; Nelms *et al.*, 1994; Gilger, 1997). The only disadvantages are the cost and learning curve of this procedure.

Phacoemulsification

For the good outcome of surgery are critical:

1) selection of the patient
2) surgical technique
3) perioperative screening and therapy

Adequate history of the case and general examination should be done in all patients to reveal systemic diseases accompanied by cataract (e.g. diabetes), discover any underlying ocular (Vlkova *et al.*, 1991) or systemic disease, that would affect the surgery or anesthesia protocol, and exclude extremely hyperactive or aggressive patients from the surgery (in such patients the post-operative rest, treatment and check-ups might be very difficult). Preoperative examination should include complete ophthalmologic exam. Intraocular pressures (IOP) are taken to check for underlying glaucoma/uveitis (Hlinomazova and Vlkova, 2003; Vlkova and Hlinomazova, 2003). Thorough slit lamp examination/biomicroscopy should reveal any visual interference in cornea (opacity, edema, pigmentation) or anterior lens capsule plaques suggest possible similar changes on the posterior capsule (Nasisse and Davidson, 1991) and the state of suspensory apparatus of the lens (signs of lens sub-/luxation). Thorough fundoscopy should be done, if possible, to exclude any abnormalities such as retinal detachment or progressive retinal atrophy (PRA). Especially in cases where fundus is not visible through the lens, the electroretinography (ERG) examination is advisable (especially in breeds with predisposition to PRA). USG examination can reveal retinal detachment and vitreal degeneration or hemorrhages (Van der Woerdt *et al.*, 1993).

**Timing of the surgery**

Contrary to the timing for performing ECCE (surgery at stage of mature cataract), phacoemulsification should be done as soon as possible. There are several reports indicating that delay in surgery can lead to untoward outcome during surgery in case of mature/hypermature cataract (Fischer, 1972; Paulsen *et al.*, 1986; Van der Woerdt *et al.*, 1992), possibly due to phacolytic uveitis, plaques on posterior capsule and/or zonular instability. Another controversial question is whether to operate both eyes at the same time or perform two separate surgeries; each of these has both advantages and disadvantages (Davidson *et al.*, 1990).

**Preoperative medication**

There are numbers of different protocols used prior to cataract surgery (Dziezyc *et al.*, 1989; Dziezyc, 1990; Williams *et al.*, 1996; Nasisse and Davidson, 1991), the selection depends on the surgeon's preference, type of surgery performed and according to West (in Williams *et al.,* 1996), even on specific reactivity of patients in different regions. However, most protocols are aiming at three targets; suppression of inflammation (topical steroids and/or NSAIDs several days/hours ahead of surgery), elimination of infection (broad spectrum antibiotics several hours to days prior the surgery, or intracameral application of adrenalin at the time of surgery [Peterson-Jones and Clutton in (Williams *et al.,* 1996)]. Most surgeons also use single intravenous application of flunixin meglumine at the time of induction of anesthesia.

**Anesthesia**

In human medicine majority of the uncomplicated cases are operated in local anesthesia (Atkinson, 1948; Bloomberg, 1991; Fichman, 1996), the complicated cases in general anesthesia – systemic neuromuscular blocking (Davis, 1994).

The use of ketamine sedation during human cataract surgery is being looked into in a study to evaluate the possibility of use of the anesthetic for intraocular study. The use of ketamine in ophthalmic surgery has been investigated: ketamine combines analgesic and sleep producing effects without significant cardiovascular and respiratory depression. Reported literature suggests use of ketamine as a potent anaesthetic for the paediatric population (Raju, 1980). While performing surgery under ketamine induced sedation, Cugini *et al.,* 1988 concluded it did not influence IOP and enabled comfortable completion of surgery.

In a study to determine the effectiveness of ketamine for paediatric surgery, it was used in children with treatable vision impairing condition where availabity of surgical care and anaesthesia was scarce. It was concluded that ketamine is effective for intra as well as extraocular surgery and the surgery was carried out safely because of its simplicity and safety. Ketamine may be useful in simple ophthalmic set up in the developing world (Pun *et al.,* 2003).

In veterinary medicine general anesthesia is evidently imperative. A general review of anaesthetic techniques for ophthalmic surgery was reported (Crispin, 1981) and control of intraocular pressure by hyperventilation (Clutton *et al.,* 1988). Cataract extraction under short acting anesthetic such as thiopental sodium has been done; major constraint is the rotation of the globe, which needs repeated correction (Gelatt, 1985; Hazra and Samanta, 1999).

Infusion with local anesthesia lidocaine intraoperatively provides analgesia similar to morphine during intraocular surgery in dogs (Smith *et al.,* 2004). Most surgeons prefer systemic neuromuscular blocking agents, because it markedly simplifies the procedure by eliminating bulbar rotation (Dziezyc, 1990; Nasisse and Davidson, 1991).

The use of Xylazine along with Ketamine for intraocular surgery in dogs, helped to reduce the intraocular pressure along with improvement in pupillary size (Kilic and Unsaldi, 2005).

**Incision**

There are three possibilities for access to the lens: clear corneal, limbal or scleral-based approach. Comparison of these was published (Nelms *et al.,* 1994). In dogs the lens is most easily accessed by clear corneal incision, which is also the easiest to create; on the other hand it leads to greater degree of astigmatism and fibrosis and it is more critical to precisely appose wound edges to achieve water tightness. Posteriorly placed incisions induce lesser astigmatism, heal faster with less fibrosis, but are more difficult to create and what is more important, there is more chance to touch the iris and much higher tendency to iris prolaspse. Also the access to the lens, especially the part closest to surgeon (mostly 12 o'clock position) is complicated. Last, but not least complication of such incisions is bleeding from sclera, which can result in more complications (Nelms *et al.,* 1994; Nasisse and Davidson, 1991).

Size of incision depends on the method used. Opposed to ECCE ($190^{o}$ of limbal circumference, or approximately 20-22 mm), standard incision for phaco is 3.2 mm, which is in case of implantation of PMMA lens widened to 8 mm (Nasisse and Davidson, 1990), in case of foldable IOL to 4.2 mm (Gaiddon *et al.,* 1997), with injector even smaller (3.8mm). With bimanual technique, one side port, approximately 1 mm wide, oriented toward the surgeon's non-dominant hand is created in limbus.

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**Capsulotomy**

Provided with different instruments (cystotome, hypodermic needle, Vanas scissors, capsulorhexis forceps), the most common method of capsulotomy is continuous curvilinear capsulorhexis (Gimbel and Neuhman, 1990). For ideal stability of IOL the capsulorhexis should be circular, with diameter 1 mm smaller than the optic part of IOL (Nasisse and Davidson, 1991).

**Hydrodissection**

Hydrodissection enables division of the lens material from the capsule using application of solution between the capsule and the lens through 27G cannula. In some cases (one-handed techniques, hard cataracts) it can be useful to perform hydrodissection after sculpting the nucleus (excluding free movements of nucleus) (Nasisse and Davidson, 1991). In some bimanual techniques, especially in cases of hard nuclei, hydrodelineation (separation of different levels of the lens nucleus) is also used.

**Phacoemulsification technique**

The principle of phaco is to sculpt and fragment the nucleus and subsequently remove it by aspiration and aspirate all remaining cortical material (Kelman, 1994; Nasisse and Davidson, 1991). During the three decades plenty of techniques have been developing. The main regimentation would be one handed versus bimanual techniques, anterior versus posterior fragmentation and fragmentation after completing CCC.

Jacob *et al.* (2002), studied the feasibility, risks and postoperative outcomes of phacoemulsification with posterior chamber intraocular lens implantation in cases of white cataract with the use of trypan blue as an adjunct for performing CCC and observed that phacoemulsifiaction using trypan blue was safe and effective in managing white cataracts and had a high success rate. Further studies were conducted on the safety and usefulness of trypan blue application and conventional endoillumination for enhancing visualization during phacoemulsifiaction. Results indicated Trypan blue application improved visualization of the anterior capsule and a complete capsulorhexis could be performed (Yamamoto Narumichi *et al.*, 2005).

One-handed technique has the advantage in the possibility of using the non-dominant hand for manipulation with the globe and it is easier to learn. On the other hand it is more complicated to reach all parts of the lens (especially the part closest to the surgeon, most commonly the 12 o'clock position). It also necessitates manipulation close to the posterior capsule, disadvantage of this technique is the risk of posterior capsule perforation with the second instrument and longer time to master it.

With bimanual techniques the surgeon uses his second hand to manipulate the nucleus with special intraocular instrument through the side port. This is particularly useful with hard canine nuclei, where it enables manipulation far from the posterior capsule. The second instrument can also help to push hard fragments towards and into the phaco needle. The main disadvantage of this technique is the risk of posterior capsule perforation with the second instrument and longer time to master it.

Phacoemulsification in the anterior chamber increases the risk of corneal endothelium damage. That is why it should be performed exclusively within the lens capsule (posterior chamber phacoemulsification). Attempts to protect the endothelium even further, led to development of endocapsular techniques, or phacofragmentation and aspiration through a small incision in the anterior capsule and finishing the capsulorhexis afterwards (Obstbaum, 1987; Gaiddon *et al.,* 1988).

One of the safest methods towards intervention of intraocular structures is nucleofraction. The first to refer on this method was Kelman, but he was working in the anterior chamber. Gimbel's "divide and conquer" (Gimbel, 1991) is considered to be the basic technique using nucleofraction. This bimanual technique was modified by Shepherd who the first to divide the nucleus in a cross method (Sherperd 1990). In 1993 Nagahara introduced a new technique of phacofragmentation, "phaco chop" (in McKool, 1998). Phaco Chop was successfully done in dogs by Warren, (2004), although translation of the method for veterinary patients required modifications. In 1996 Pfeiffer published the next modification, "phaco-crack". Maloney's supracapsular phacoemulsification is a different method that enables to shorten the phaco time by half (Fine, 1993). In dogs, due to a harder nucleus compared to humans, surgeons prefer to use combinations of mentioned methods.

**Irrigation/aspiration**

After emulsification of the nucleus, it is necessary to remove all remaining cortical material to avoid post-surgical complications (Nasisse and Davidson, 1991). One can use either bimanual, or one-handed irrigation/aspiration (I/A), the latter being the method of choice for most surgeons. After I/A, the posterior capsule is polished with I/A tip (set to very low vacuum) or with different types of capsule polishers.

**Types of IOL**

IOLs are used for optimal correction of aphakia. In 1949 Harold Ridley first started modern era in implantology. He implanted the first polymethylmetacrylate (PMMA) posterior chamber IOL (Ridley 1952). With further advances towards anterior chamber lenses; the first of its kind was implanted by Strampelli in 1951 (Linebarger *et al.,* 1999). The next achievement was the introduction of the iris-supported lens by Binkhorst (Binkhorst *et al.* 1972). Since the year 1949 the most widely used material has been PMMA. Development of soft, foldable IOLs started in 1984 (Mazzocco, 1984)

**Materials of intraocular lenses**

The important characteristics of IOLs are: density, refractive index, optical transmittance, dimensional stability, mechanical properties, biocompatibility, toxicity and chemical stability.

1. Thermoplastics

PMMA – polymethylmetacrylate is a polymer of methylmetacrylate monomer. It is light, durable, has refractive index 1.49. It is well tolerated, although it is not totally inert material. PMMA lenses are rigid; implantation is completed through a 6-8 mm incision.

2. Synthetic elastomers

Silicon is biocompatible flexible and elastic material with refractive index of 1.41-1.46. One of the disadvantages of silicon lenses is that they get damaged in contact with silicon oil (condensation in the lens); that is why they should not be used in patients with possibility of future need of vitreoretinal surgery (e.g., patients with diabetes).

3. Acrylate polymers

Hydrogel and hybrid hydrogel lenses (Barrett 1991; Barrett 1994). The basis of all hydrogel polymers is acrylic hydrophilic monomer HEMA with a refraction index 1.43-1.48. Individual lenses differ in material composition and amount of water. One of the best-tolerated lenses is monoblock (it is made out of 1 piece), with low content of water; in 16-18% there is an occurrence of minute posterior capsule opacification (PCO).

4. Soft acrylic IOLs (Oshica, 1996).

It is hydrophobic lens with refractive index 1.47-1.55. It is biocompatible, foldable, with minimal occurrence of PCO.

*Collamer IOLs*

A new material which is the combination of silicon and collagen. This material is used for cataract as well as for refractive surgeries, due to its high refractive index through incision even smaller than 3.2 mm (Kecova and Nicas 2004)

*Soft lenses*

After introduction of phacoemulsification, the research was directed towards invention of foldable lenses (Kohnen 1996), which would allow implantation through small incisions, thus minimizing astigmatism and post-surgery complications (e.g., fibrin reaction, infection). The most common materials are silicon elastomers and acrylate/metacrylate polymers. The implantation of soft lenses is achieved through 3.2-4 mm incision, depending on the size of the lens and the way of implantation (forceps, injector).

**IOLs in dogs**

The first implantation of intraocular lens in man was reported by Harold Ridley in England. The IOL was placed between the iris and the anterior capsule. Simpson in 1956 was the first to implant IOL in dogs in America. He compared 11mm diameter IOL for intracapsular placement and 14mm diameter IOL positioned in front of the posterior lens capsule. Olson in1980 evaluated the shearing IOL in the dog considering that canine ciliary body sulcus diameter is approximately equal to that in man.

Inspite of controversies regarding whether or not to implant IOL in dogs (Bigelbach, 1994), at present time most surgeons tend to implant (Nasisse *et al.*, 1990; Davidson *et al.*, 1991; Gaiddon *et al.*, 1991; Gilger *et al.*, 1993a; Nelms *et al.*, 1994; Gaiddon *et al.*, 1997). There are two main types of IOLs used in veterinary medicine – hard (PMMA – Gilger *et al.* 1993 b) and foldables – silicon (Gilger *et al.*, 1993 b; Gaiddon *et al.*, 1997) and acrylic polymers. The lenses are implanted within the capsular bag; the anterior chamber and iris-supported lenses are not used due to high extent of complications (Nasisse and Davidson, 1991). The optic power is most commonly 41D (Gaiddon *et al.*, 1991), the sizes differ from 14 to 18 mm (haptic size), with 7 mm optic.

Most implanted lenses in dogs are PMMA, although recently many surgeons tend to use soft, foldable lenses. Gaiddon *et al.* (1997) described use of silicon lens. The latest type of soft lenses designed for dogs are made of hydrophilic acrylate. The undeniable advantage of acrylic lenses is the size of incision as well as the excellent biocompatibility. On the other hand, PMMA lenses cannot generally be substituted in the cases of implantation in the capsule of subluxated lenses or where the posterior circular capsulorhexis is necessary due to fibrosis.

Owing to better equipment and more precise, microsurgical methods, the success rate of cataract extraction in dogs has raised significantly. In the recent times with the introduction of foldable materials there is a possibility of faster postoperative rehabilitation of patients together with minimal intraoperative damage of ocular tissues. The future will reveal all advantages and differences between hard and soft IOLs implanted in dogs. Regardless of which type of lens is implanted, if all necessary criteria for good outcome are fulfilled (selection of the patient, correct surgical technique, adequate equipment) this common disease of dogs can be successfully treated (Kecova and Necas, 2004).

**Post operative complications following phacoemulsification in dogs**

Post operative complications caused by phacofragmentation/aspiration are common to standard extracapsular lens extraction procedures in dog, such as, fibropupillary membranes, postoperative uveitis, synechiae and corneal opacity.

Fifty six cases of cataract removal in dogs by phacofragmentation and aspiration were reviewed (Miller *et al.,* 1987). Immediate postoperative improvement of vision was detected in 94.6% dogs. After 2 years, 85.2% retained vision and 71.45% after 4 years. Causes of failure were mainly attributed to postoperative anterior uvietis. Post operative opacification of an initially clear posterior capsule is a frequent complication following cataract surgery.

Histopathological features of postoperative complications following phacoemulsification were studied experimentally in dogs by evisceration and enucleation and correlated to clinical abnormalities, the most frequent histopathologic diagnosis was glaucoma (76%) and retinal detachment (64%) and clinically glaucoma (86%) and uvietis (82%). Five problem areas were identified that appear to make a significant contribution to the failure of canine cataract surgery, Preiridal fibrovascular membranes, lens fiber regrowth, lens epithelial membranes, endopthalmitis and the health of the corneal surgical incision (Moore *et al.*, 2003).

Post operative complications due to intraoperative contamination of the anterior chamber with viable microorganisms during phacoemulsification was assessed (Ledbetter *et al.,* 2004), and concluded that contamination of the anterior chamber with viable microorganisms, bacterial or fungal is a common occurrence, which is independent of the patient and surgical variables investigated.

Posterior capsular rupture during routine phacoemulsification was documented and postoperative outcomes and complications in eyes with posterior capsular disruption were compared with eyes with intact posterior capsules. The most significant complication of posterior capsular disruption was the inability to implant an intraocular lens (Johnstone and Ward, 2005).

Long term complications after phacoemulsification for cataract removal in dogs were reviewed (Sigle and Nassie, 2006) and mild posterior capsule opacification was found to be the most common complication. Retinal detachment was uncommon (1% to 2%) for all time periods. Prevalence of glaucoma increased with time, although it remained less than 10% until after the 1 year follow up period. Breed predilection for glaucoma included Boston Terriers, Cocker Spaniels, Cocker Spaniel-Poodle crosses and

Shih Tzus had increased risk of developing glaucoma. Eyes with hypermature cataract were more likely to develop cataract.

Intraocular pressure (IOP) elevation after cataract surgery has been documented in humans for 40 years. An increase in IOP immediately after cataract extraction was first reported by Gormaz, (1962).

Miller *et al.* (1997) investigated the mechanisms of increase in IOP after phacoemulsification in clinically normal dogs and observed sudden increase in IOP with few overt clinical signs may occur immediately after lens extraction in dogs. Structural alterations in the trabecular meshwork persist after IOP has normalized in 24 hours and may contribute to the genesis of glaucoma. Similar changes with clinical cases of cataract were observed by Smith *et al.* (1996), and advocated routine use of anti glaucoma medications in the first 12 hours after surgery.

Intracameral administration of Carbachol at the end of surgery i.e. Phacoemulsification in dog, showed none of the dogs treated with Carbachol developed postoperative ocular hypertension whereas 12 out of 16 control dogs had ocular hypertension 3 hours after surgery, it was concluded intracameral administration of 0.01% carbochol at the end of the surgery was a safe and efficacious method of preventing post operative increase hypertension (Stuhr *et al.*, 1998).

Studies were conducted to determine the factors contributing to glaucoma after lens extraction by phacoemulsification. It was identified that eyes at increased risk for glaucoma included those of Boston Terriers, those with uveal or retinal abnormalities before surgery and those with intraoperative intraocular haemmmorage. Mixed breed dogs were at significantly lower risk for glaucoma. Eyes with IOL placement were at significantly lower risk for glaucoma (Biros *et al.*, 2000; Lannek and Miller, 2001).

While comparing the changes in post operative IOP following extracapsular and phacoemulsification in 50 dogs, no significant difference of mean intraocular pressure between the two surgical methods was observed. A decrease in IOP after 1 hour post operative was followed by rise between 3 to 5 hours and again normal values were obtained at 18 hours, 1 week and 1 month post surgery. It was concluded that a follow up of IOP was required in the first few hours after cataract surgery to avoid complications of the retina and optic nerve (Chahory *et al.*, 2003).

**Learning curve of Phacoemulsification**

One of the most challenging aspects for a surgeon is to remain update in terms of knowledge and procedural techniques. Certainly the field of cataract surgery offers this challenge. After critically evaluating the learning curve of residents learning phacoemulsification it has been derived that an average surgeon requires 50 cases before one is comfortable with the process (Glover and Constantinescu, 1997).

A study was designed to investigate the feasibility of teaching experienced surgeons to perform phacoemulsification, complications occurring during surgery and the first postoperative day were documented and evaluated, the most common complication was rent in the posterior capsule which occurred in 13.3% eyes. There were significant variations in complication rates and in surgical time among the surgeons. The risk of experiencing complication decreased as the number of phacoemulsifications performed increased (Robin *et al.*, 1997).

In a retrospective study review of the first 102 cases of phacoemulsification procedure performed by two residents, posterior capsular tear occured (5.8%), vitreous loss in (2.9%) despite which it was concluded that junior trainee can be taught phacoemulsification with acceptable complication rates (Prasad, 1998).

In another study the peroperative complications performed by an experienced consultant surgeon was assessed during the first 3000 cases of phacoemulsification .The overall rate of vitreous loss was 1.3%. Nuclear fragments were lost to the vitreous (0.2%). The initial rate of vitreous loss was 4% in the first 300 cases falling to 0.7% in the last 300 cases it was concluded that per operative surgical risks could be reduced to low levels during the learning curve (Martin and Burton, 2000).

To assess the risk factors for endothelial cell loss after phacoemulsification, performed by a junior resident, it was observed that the mean overall endothelial cell loss was 11.6%. This study also supports the fact that proper selection of cases will help to reduce the phaco time and thus minimize endothelial loss (Brien *et al.*, 2004).

In order to evaluate the visual outcomes after vitreous loss during cataract surgery of 1400 cases 4.5% cases of vitreous loss was indentified. No patient with vitreous loss developed a retinal detachment or endopthalmitis, good visual acuity can be achieved after resident cataract surgery complicated by vitreous loss (Bloomquist and Rugwani, 2002).

In a prospective study comprised of 100 consecutive cases of phacoemulsification performed by 8 trainee surgeons over an 11-month period, the trainee surgeons found phacoemulsification and capsulorhexis are the most difficult stages of cataract surgery early in the learning curve. It was concluded that more time can be dedicated to master these steps in the wet lab ( Dooley and O'Brien, 2006).

**Models of cataract for practice of phacoemulsification.**

It has been established that although phacoemulsification is now the technique with highest success rates for cataract removal both in human as well as veterinary ophthalmic surgery, the fact remains that this technique has a steep learning curve. It is technically more difficult to master than traditional methods of lens extraction. For most surgeons learning phacoemulsification, the single most crucial step is to master the continuous curvilinear capsulorhexis (CCC). Lack of basic understanding of the principles of CCC can lead to frustrating complications. Since the learning curve for phacoemulsification is long, wet lab training is considered essential. Several reported experimental models have been devised for surgeons attempting to master phacoemulsification.

In an attempt to create cataract in post mortem pigs' eyes by injecting the lens with mixtures of formalin and alcohol 0.2ml, cataract developed within 15 minutes (Suguira *et al.,* 1999). Viscoelastic endothelial protection and formaldehyde-methanol mixture have been used to create cataract in pigs' eye (Vinicus and Fabiot, 2003) but the characteristics of the lens nucleus and capsule in these eyes are different from human eyes with senile cataract. Cataract was induced in pig's eyes by placing them in micro-oven for 9 seconds. Although a hardened nucleus was obtained it weakened the capsule and zonules (Van Vreewijk and Pameyer, 1998). Cooked chestnuts of various hardness filled into pigs eyes, have been as practice models for phacoemusification (Mekeda *et al.*, 1999).

An inexpensive, easily prepared modified model using a post mortem pig eye was created for training ophthalmology residents to perform continuous curvilinear capsulorhexis, the tension and elasticity of the porcine anterior lens capsule was reduced by injecting 0.05ml of formaline mixed with hydroethylcellulose or a viscoelastic into the anterior chamber. The mixture of formalin with viscoelastic reduced the diffusion of formalin and allowed anterior capsule fixation without damaging the corneal endothelium (Hashimoto *et al.*, 2001).

Pandey *et al.* (2000 b) described a training model using human enucleated post mortem eyes by injecting paraformaldehyde and glutaraldehyde, although it simulates cataract in humans, lack of availability and ethical reasons limited this method.

Cataract in goats eyes were induced by injecting 20% formalin after performing CCC (Dada and Sindu, 2000). This method too has its drawback, corneal clouding was observed as a result of endothelial toxicity of formalin.

The continuous curvilinier capsulorhexis technique can be a difficult technique for the begining ophthalmology surgeons, a haptic surgical simulator for the continuous curvilinier capsulorhexis has been designed by Webster *et al.* (2004).

A surgical training system for teaching and practicing the necessary skills to perform phaco was devised (Maloney *et al.*, 1988). The surgical system included head bilateral globes and removable corneas and replaceable synthetic cataract of varying density.

Human cataractous lens removed with its capsule intact was implanted in either the anterior or posterior chamber of the rabbit eye provided a model system that simulated a clinical case of human cataract. Human lens nucleus has been implanted in a deep cavity in the lens of an enucleated sheep eyes. This experimental practice model is prepared with a human cataractous lens of a preferred hardness (Tolentino and Liu, 1975; Kayikcioglu *et al.*, 2004).

Cataracts of varing degree of hardness in human eyes were obtained by injecting 0.2 ml of Karnovsky solution into the lens nucleus of the eye. This model was used to practice extracapsular cataract extraction and various two handed phacoemulsification maneuvers (Pandey *et al.,* 2000, a)

In vitro bovine eye has also been used to practice phacoemulsification (Coroneo, 1990). A simple reliable method of practicing intraocular surgery using rigid contact lens as a temporary keratoprosthesis, which allows clear visualization of the anterior chamber and lenticular structures for practicing modern cataract surgery has been devised (Castellano *et al.,* 1998).

The severely edematous human cadaver eye model to practice phacoemulsification would be difficult. Attempts to improve this condition by injecting medical lubricating jelly was successful, within 10 minutes, excellent corneal clarity was achieved (Liu *et al.,* 2001).

Apart from wet lab training, uses of special devices have been reported for training of ocular surgery (Porrello *et al.,* 1999). Computer simulated phacoemulsification has also been experimented (Laurell *et al.,* 2004). These methods can give surgeons a false sense of security and the surgeon can be evaluated only objectively. Another major problem mentioned with method is that the development of virtual reality applications is expensive and time consuming.

Live model of cataract has been created in dog with 2, 6 disophenol at a dose rate of 30 mg/kg S.C. (Martin, 1975). Cataract was experimentally produced in orphan puppies fed on commercial replacement for bitch's milk but the opacities were mild and decreased with time (Martin and Chambreau, 1982).

**Histopathological features of cataractaractous lens in various cataract models.**

The models of cataract that have been clinically proven had also been established histologically. The histologically features of lens in different types of cataract in different species has been reviewed.

Transcorneal injury to the lens is a high cause of traumatic cataract in human and frog, similar model was studied the mice. It was observed that it elicits a repair process in the mouse lens whereby the damaged capsule, epithelium and lens fibers are rapidly renewed and permanent lens opacity seldom occurs (Fagerholm,. and Philipson 1979,a). Ultrastuctural differences between mouse and human lens such as presence or absence of dense bundle of micro filaments and desmosomes are considered in relation to lens shape and susceptibility to injury induced cataracts (Rafferty and Goosens, 1975).

Morphology of hereditary cataract was examined by light and electron microscopy. Usually dense fibers at the bow area and swollen fibers in the posterior cortex were observable by just 2weeks of age. At 4 weeks of age, the appearance of the dense fibers at the bow area became more frequent, and the lenticular nucleus was formed at the center of the lens. At this time, the cellular extensions of the posterior cortical fibers began to be interrupted around the posterior sutural area, following this change; small amounts of liquid were accumulated at the posterior subcapsular region, just behind the bow area by 6 weeks of age. By 10 – 11 weeks, increased areas of liquefaction extended into almost all posterior subcapsular region and as the posterior suture line separated the opacification rapidly appeared (Uga and Ihara, 1990).

The histological features of traumatic cataract caused by injury to the anterior part of the lens were studied with procion yellow as an extracellular tracer and by transmission electron microscopy at different time intervals. Swelling of lens fiber cells and formation of large syncytical aggregates were found as the posterior opacity enlarged. In the rabbit lens a slight cellular swelling was seen in the subcapsular cortex. One out of 15 lenses showed posterior sub capsular opacity after about 1 week in spite of a large wound. No further penetration of the dye occurred through the wound, after the epithelium by regeneration had sealed the wound (Fagerholm, 1979,c).

In order to shed some light on the origin of cataract by various factors, an experimental model of cataract was induced in lens of a Japanese monkey. Clinical examination revealed opacity of the posterior subcapsular cortex. Electronmicroscopic investigation revealed that lens fibers within the opaque region had increased number of mitrochondrion, the intracellular space in the opaque region increased and large extracellular vacuoles were formed. The morphological changes showed acceleration of water absorption of the lens fibers from a relatively early stage of traumatic cataract (Katsume *et al.,* 1983).

Different stages of cataract formation secondary to eye trauma were subjected to quantitative micro radiographic or electron microscopy. Anterior and posterior sub capsular cataracts were found to contain extensively swollen lens fibers in the sub capsular cortex. There was reduced concentration of dry mass in the sub capsular cortex around the whole circumference of the lens. The inner cortex and nucleus appeared normal. Opaque-cataract membrane and the Soemmerring's ring were features observed in some cases (Fagerholm and Philipson, 1979, b).

Healing response of the capsule of the lens to varying sizes of perforating injury showed the size of the injured area is a determinant of repair or opacity and the site of opacity is dependent on the severity of epithelial damage and location of the liquefied area (Wakasugi *et al.,* 2002).

Although the usual senile cataract is not apparent on the CT, however the CT scan reports of traumatic cataract showed presence of a unilateral hypodense appearance within the lens caused by increased fluid contents, similar changes can be expected in osmotic cataract caused by diabetes (Segev *et al.,* 1995).

# MATERIALS & METHODS

# Materials and Methods

## Materials and Methods for creating cataract in rat and dog

**Materials:**

a) **Instruments:** 26 gauge bevelled needle, lid retractors, and conjunctival forceps.

b) **Anaesthetics:** Inj Ketamine Hcl (Ketmin 50) ® Themis medicare Ltd, Mumbai, India. Inj Xylazine Hcl. (Xylaxine) ® Indian immunologicals Ltd. Mumbai. India. Inj Atropine Sulphate (Tropine) ®, Neon Labs .Inj Thiopentone (Thiosol sodium)® Neon Labs, Mumbai.

c) **Medication:** Topical Atropine sulphate 1%, (Atropine)®, Jawa pharmaceuticals (India) Pvt. Ltd. Chloremphenicol eyedrops (Bromycetin)® Martin and Brown Pharmaceuticals, India. Flubiprofen eye drops (FNB eye drops)®, Microlabs Ltd. Topical Prednisolone acetate ophthalmic suspension USP,( Allergan)®, Nicholas Piramal India Ltd. Injection Triamcilone (Tricort)®. Cadila India Ltd. Inj Enrofloxacin 10% (Floxidin vet)®,Intervet India Pvt. Ltd. Phenylephrine (Decomic®, eye drops, Klar Sehen Pvt. Ltd., India), and Cyclopentolate (Cyclopent®, Sun, India )

**Methods:**

Rat: This study was conducted with prior permission of the Institutional animal ethics committee. All animals used in this study were treated in strict accordance with institutional guidelines and with the tenets of the Association for Research in Vision and Ophthalmology (ARVO) statement for the use of animals in the ophthalmic and vision research. Ten healthy rats weighing of 250 gms were selected; basic ophthalmic examination was done clinically to eliminate preexisting ophthalmic abnormalities.

Preoperatively mydriasis was achieved by instillation of topical atropine sulphate1%,and phenylephrine10% from one day prior to induction at 8 hrly interval, preoperative anti-inflammatory Flubiprofen, was instilled twice daily from one day prior to surgery.

**Anaesthesia:**

Anaesthesia was achieved with Xylazine Hcl @ 5mg/kg I/M and Ketamine @25mg/kg I/M.

**Technique:**

Each rat was placed in left lateral recumbency, left eye of each rat was selected for induction of cataract. The beveled end of a 26 gauge needle was used to enter the anterior chamber from the limbus; the needle was then used to puncture the anterior capsule of the lens. Post operatively, Flubiprofen eyedrops and Chloremphenicol eye drops were topically instilled for upto 7 days post induction.

Routine examinations with ophthalmoscope were done to assess the progress of cataract development and signs of lens opacity. Once cataract formation was confirmed, the rats were sacrificed, with an over dose of Inj Thiopentone intra peritonially. Lens from both the normal as well as cataractous eye were extracted and preserved in, 10% formalin for histopathological study. Tissue sections were stained with Haematoxilin and Eosin (Luna, 1968). Once the model was established in rat, the same technique was tried on dog.

**Creating the model in dog**

Ten healthy non-descript dogs of either sex, aged between 2-5 years were selected. Basic ophthalmologic examination was done to eliminate pre-existing ophthalmic abnormalities (Fig. 20). Preexisting diabetes was screened out by routine blood examination. The dogs were treated with Triamcinolone acetate 40 mg I/M one day prior to induction. Mydriasis was achieved by topical instillation of Atropine sulphate1% at 8 hrly intervals from one day before surgery. On the day of surgery Atropine1%, Phenylephrine10%, and Cyclopentolate 1%, were instilled every 30 min for two hours before surgery.

Premedication for anesthesia was done with inj Atropine sulphate @ 0.02 mg/kg. Anesthesia was induced by injecting Xylazine Hcl @ 1 mg/kg and Ketamine @ 5 mg/kg. The dogs were placed in lateral recumbency. Left eye of all dogs were selected for inducing cataract, for better positioning of the eyes, stay sutures on the superior rectus were given and lid retractors were placed.

The beveled end of a 26 gauge needle was passed through the limbus into the anterior chamber and a small tear in the anterior capsule was created with the needle and the needle was immediately withdrawn. The eyes were treated topically with anti-inflammatory drug Flubiprofen and with antibiotics, chlorem phenicol eye drops for 7 days post induction, systemically, Inj Enrofloxin was continued for 5 days postoperatively. The central position of the capsule is selected, so that the peripheral portion is retained intact for a good capsulorhexis and in the bag placement of IOL during subsequent surgery.

One of the dogs which had developed cataract during the course of this study succumbed due to a viral infection, so immediately the lens of both the eyes i.e. normal as well as cataractous were extracted and preserved in 10% formalin for histopathological study.

**Material & Methods for Phacoemulsification and cataract removal**

**Materials:**

**Instruments**

1) Phacoemulsification machine. Alcon-Universal-2-with Peristalsis Pump. /Irrigation Aspiration Unit. Fig:1(1)

2) Instruments/Sutures

i. 0.9 mm MVR-blade.
ii. Utrata forceps. Fig:2(1)
iii. Nagahara Chopper ,1.5 mm. Fig : 2(2)
iv. 26" bent cystotome.
v. Operating microscope.Inami, Japan. Fig: 1(2)
vi. 10-0 monofilament Nylon.
vii. Lens holding forceps.


Fig No. 1: 1. Phacoemulsification machine Alcon-Universal-2- with peri-
stalsis pump. 2. Operating microscope, Inami Japan

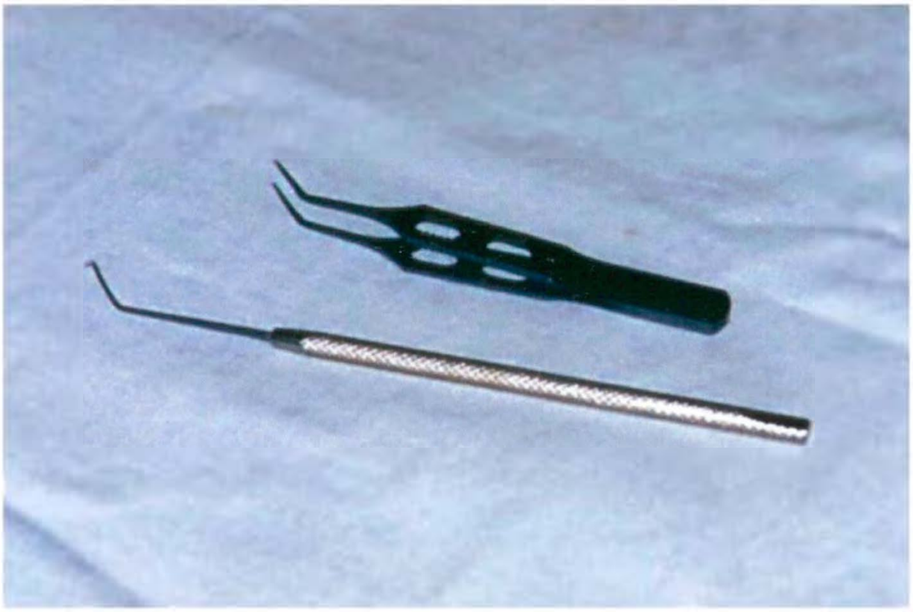

Fig No. 2: 1. Utrata forceps
2. Nagahara Chopper, 1.5 mm.

Fig No. 3: Trypan blue (Auroblue®)

viii. Rigid intraocular lens Power-33D, length 13.5mm optic-6.50mm.(Appa lens, manufactured by AOD)

ix. Ophthalmoscope – Heine Mini 2000.CE

x. Tonometer.. Schiotzc. 5112. No – 002. Rudolf Riester, Germany.

**Chemicals:**

1. Viscoelastic – Hydroxyl propyl methyl cellulose (Melose 2%)®. Optho-remedies Pvt. Ltd. Gujrat, India.

2. Trypan blue(Auroblue)®.Aurolab,Aravind Eye Hospital, Madurai, India. (Fig: 3)

**Anaesthetics:**

Inj. Atropine Sulphate (Tropine)®. Neon Labs

Inj. Xylazine Hcl (Xylaxine)®. Indian immunologicals Ltd. Mumbai. India.

Inj. Ketamine Hcl (Ketmin 50)®. Themis medicare Ltd, Mumbai, India.

Inj. Diazepam (Calmpose)®. Ranbaxy Lab Ltd. India.

Inj. 2% Lignocaine Hcl (Xylocaine)®Astra Zeneca Pharma ,India Ltd.

**Medicines:**

Topical Prednisolone(Prednisolone acetate ophthalmic suspension)®.Allegan India Pvt. Ltd.

Flubiprofen (FNB eyedrops )®,Microlabs Ltd.

Chloremphenicol eyedrops (Bromycetin)®Martin &Brown

Atropine sulphate 1% (Atropine)®Jawa pharmaceuticals India Pvt Ltd.

10% phenylehrine (Decomic)®,Klar Sehen Pvt.,India.

Inj Enrofloxacin 10% (Floxidin vet)®,Intervet India Pvt. Ltd.

Inj. Prednisolone (Prednisolone Acetate)®

Triamcinolone acetate (Tricort)$^{R}$ Cadila India.

Hypertonic saline ointment (Hypersol – 6)®. Jawa pharmaceuticals, India, Pvt., Ltd.

**Methods:**

**Criteria for selection of cases**

Nine out of ten clinically healthy nondescript dogs that were induced cataract were selected for cataract removal. All the dogs were examined for clear cornea and intact anterior capsule by ophthalmoscopy. The dogs were examined for eliminating concurrent, ophthalmic disorders. All dogs were tested to rule out elevated blood sugar.

**Pre operative Preparations.**

General preoperative management, with anthelmentics, immunizations were done. Medications used and initiated prior to surgery included topical Prednisolone acetate, Fubiprofen and Chloremphenicol eyedrops along with Atropine sulphate1% and 10% phenylephrine, were given topically, BID from two days prior to surgery and were given TID on the day before surgery and applied every 30 min for 2 hours before surgery .All dogs received Triamcinolone acetate 40 mg/I/M once, a day prior to surgery.

**Operative site Preparation**

The eyelashes were carefully removed by clipping with scissors. A little bit of petroleum jelly was applied on the hair before trimming in order to avoid dropping inside. All hair from approximate the surgical site was removed taking care to avoid nicks and abrasions of the skin. The eyelids/corneal and conjunctival surfaces were cleansed with 0.5% povidone-iodine before onset of surgery. The surrounding area was adequately draped exposing only the palpabral fissure.

**Animal positioning and anaesthesia**

All dogs scheduled for unilateral extraction were placed in lateral recumbency. The head was stabilized using a sandbag. Pre operative intraocular pressures of both eyes in all the dogs were recorded before induction of anesthesia.

**Anaesthesia**

Preanaesthetic medication comprised of Inj. Atropine sulphate @ 0.02 mg/kg. Anaesthesia was induced by Inj. Xylazine Hcl @ 1 mg/kg I/M; followed by Inj.

Ketamine, @ 5 mg/kg I/M. Anesthesia was maintained subsequently with Intravenous, Inj Ketamine and Inj. Diazepam to effect.

After anesthesia was induced retrobulbar block was done on the eye with 2% Lignocaine.

**Surgical Procedure**

*Step I*

Each dog was placed in lateral recumbency under general anaesthesia and local retrobulbar block (Fig.4). The eye position was graded by the method of (Young, 1991). Intraocular Pressure(IOP) was measured immediately after anaesthesia was achieved.

*Step II*

Lateral canthotomy was performed in respective eyes of all the dogs for better exposure of the eyeball. The eyeball position was assured by placing scleral sutures in the superior rectus and inferior rectus, and was fixed with the drapes above and below the eyeball. In one dog the nictitating membrane had completely obstructed the cornea it was retracted and full thickness suture was placed around the nictitans membrane cartilage and extended to and secured to a hemostat in the adjacent drape (Fig. 5).

*Step III*

A clear cornea partial thickness incision of 6mm in length was given to enter into the anterior chamber at the 12 o'clock position using a Bard Parkar Knife.The two side port incisions are then made with a .9 mm MVR (Microvitreoretinal) blade. Inj trypan blue with a bubble of air in the syringe (Fig. 6) was used to stain the anterior capsule and retained for 30 secs (Fig. 7). The dye was then replaced by viscoelastic substance to make the anterior chamber tight (Fig. 8). The main incision was then made with a 2.8 mm beveled down keratome. A tunnel incision was thus constructed of dimensions 2.8mm by 2mm extending into the clear cornea opening just in front of the vascular arcade.

*Step IV*

Continuous curvillinear capsulorhexis (CCC) of a diameter 5.5mm was performed using a 26 bent cystotome (Fig. 9), and the anterior capsule was removed with Utrata capsulorhexis forceps (Fig. 10). In case of one dog a miotic pupil caused hinderance in


Fig No. 4 : Animal placed in lateral recumbency.

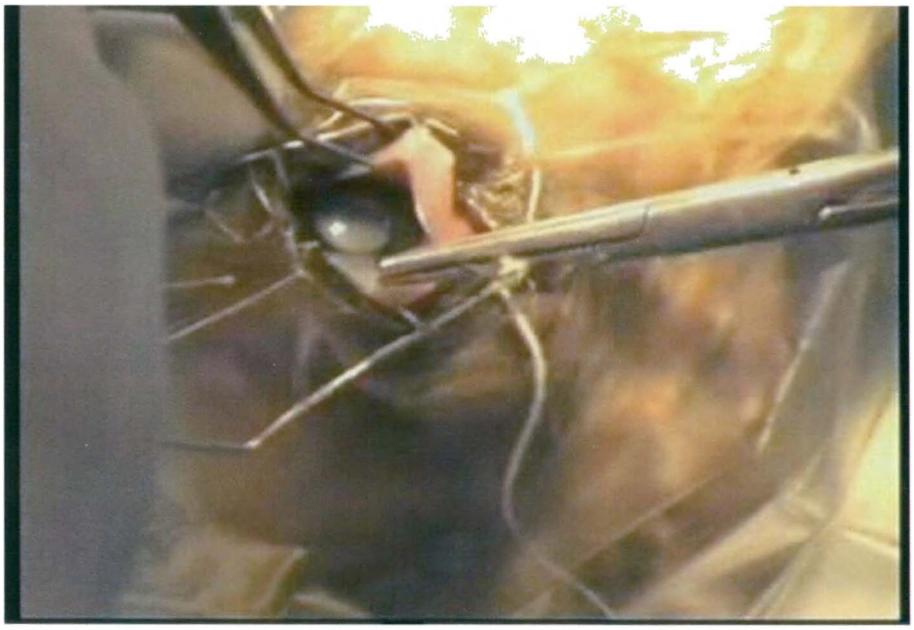
Fig No.5 : Fixation of the third eyelid.

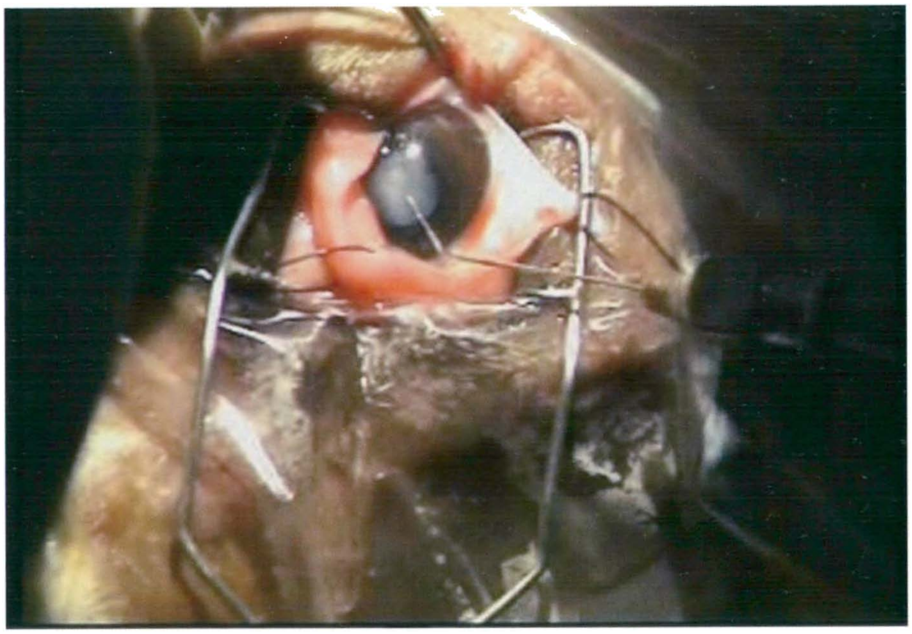

Fig No 6: Injecting air into anterior chamber prior to staining the capsule.

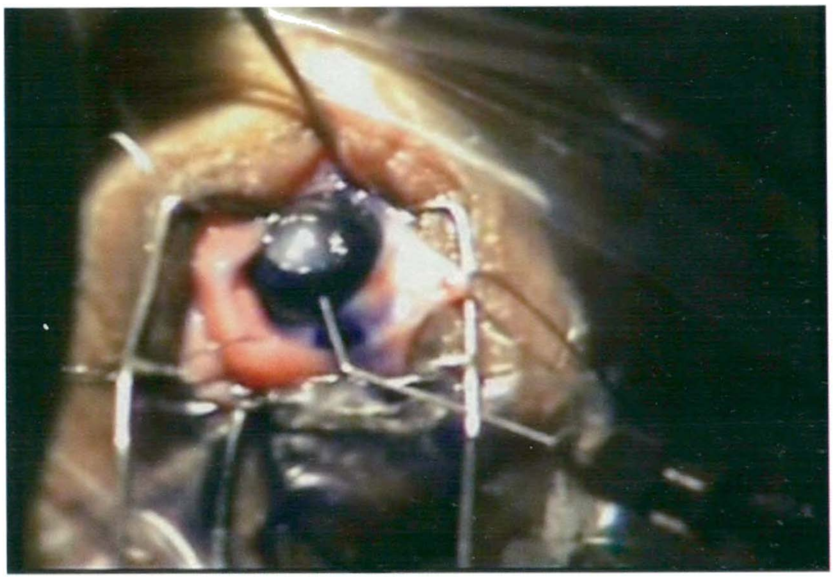

Fig No.7 : Staining the anterior capsule using Trypan blue.

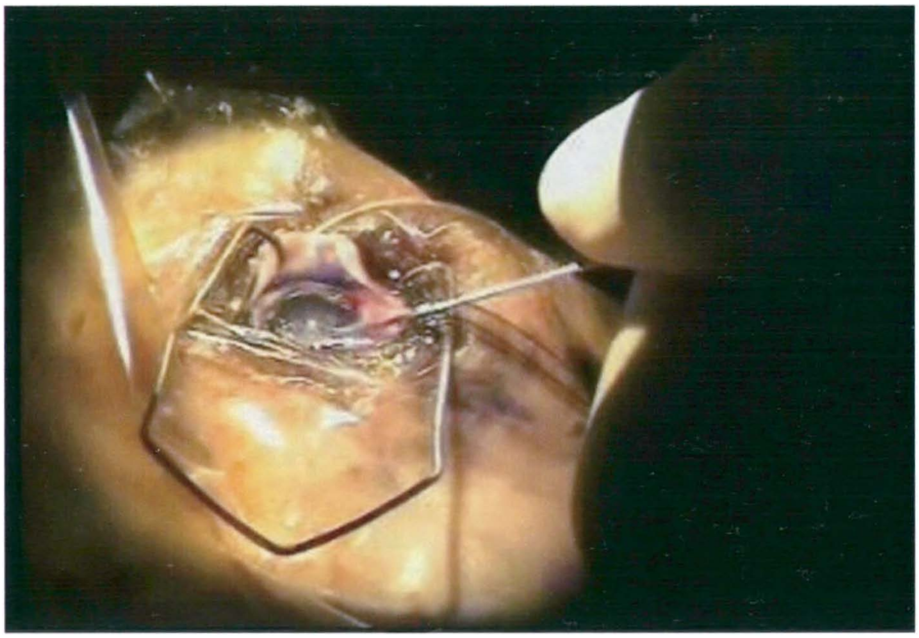

Fig No. 8: Visco elastics being injected to maintain the anterior chamber

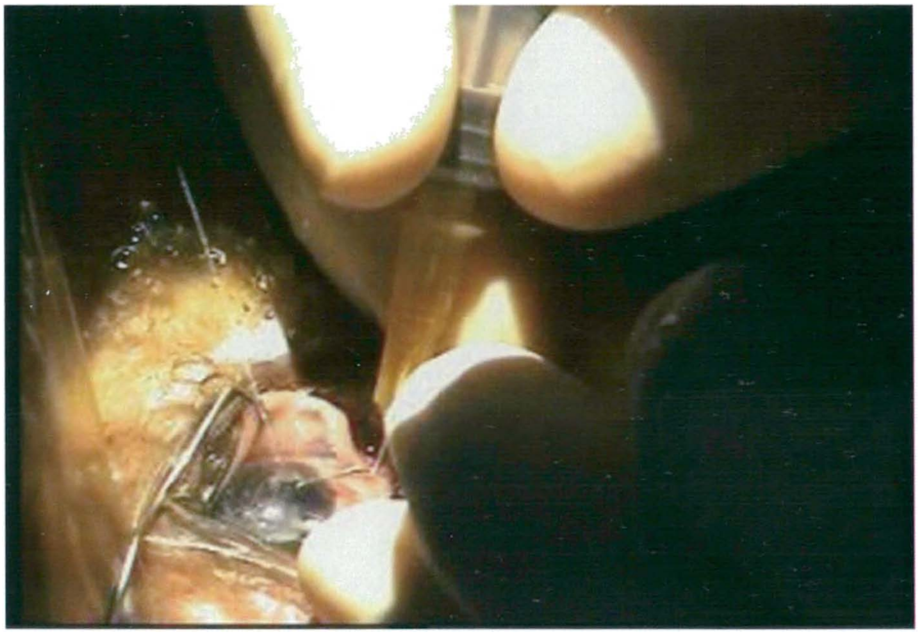

Fig No. 9: Performing CCC using 26 gauze bent cystotome.

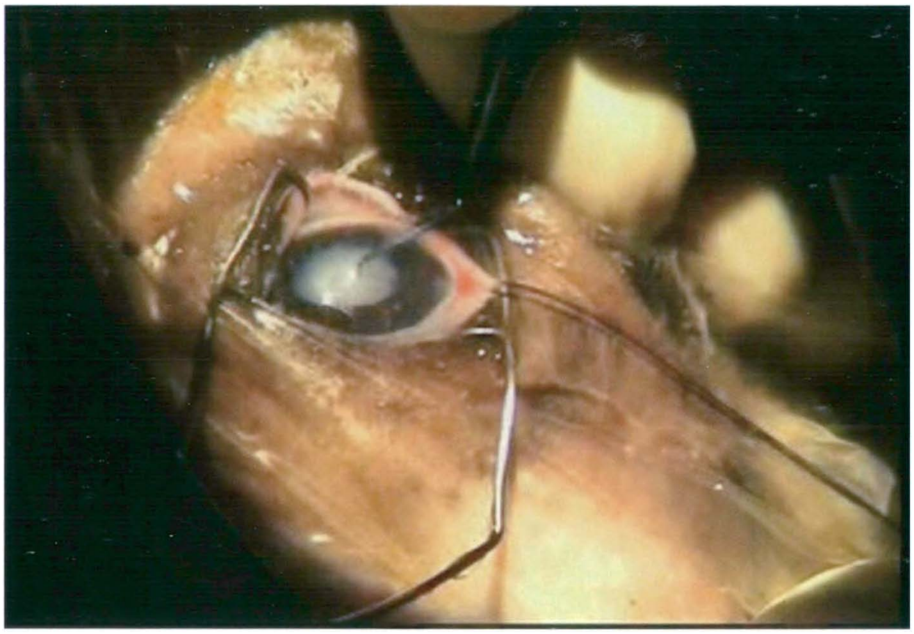

Fig No.10 : The anterior capsule being removed with Utrata Capsulorhexis Forceps.

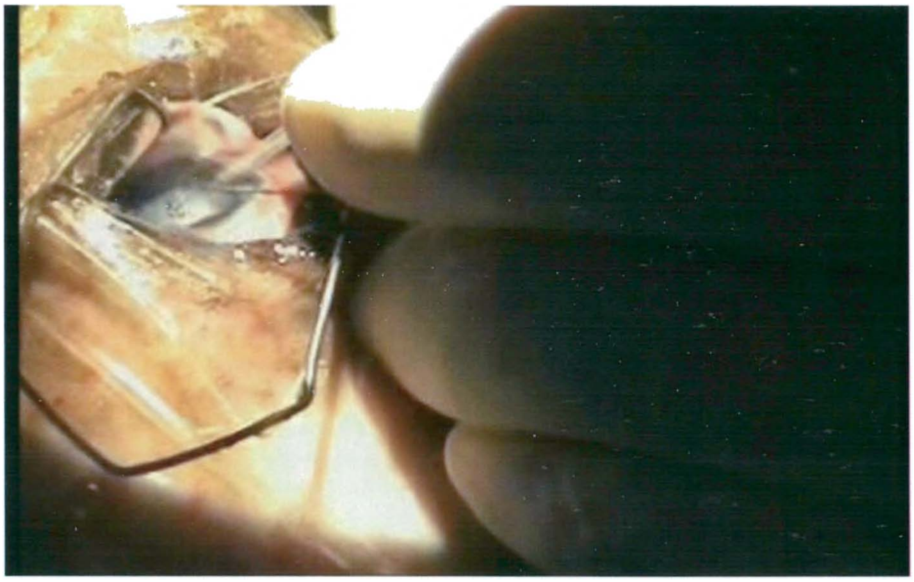

Fig No.11 : Phacochop being performed using Nagahara chopper.

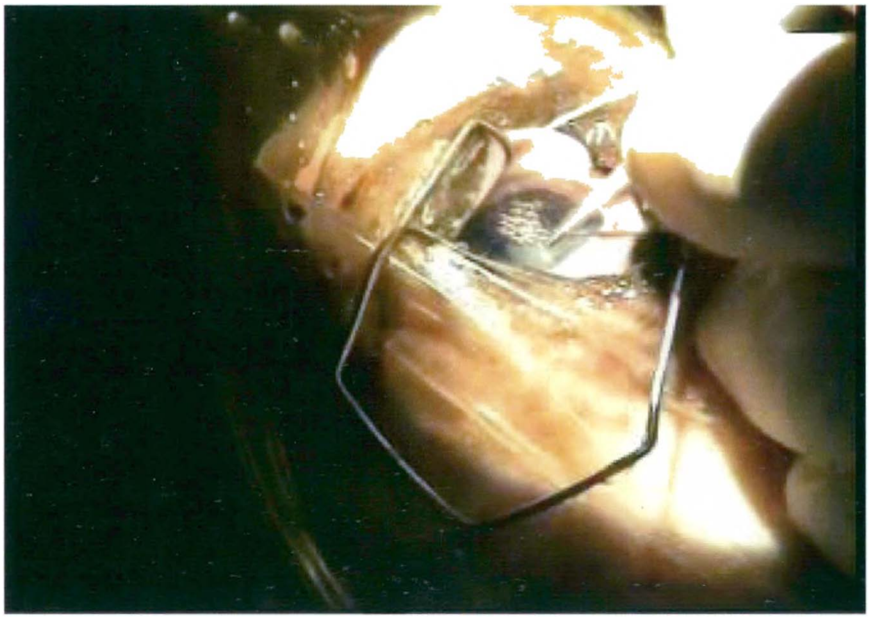

Fig No. 12: Emulsification of the lens being performed.

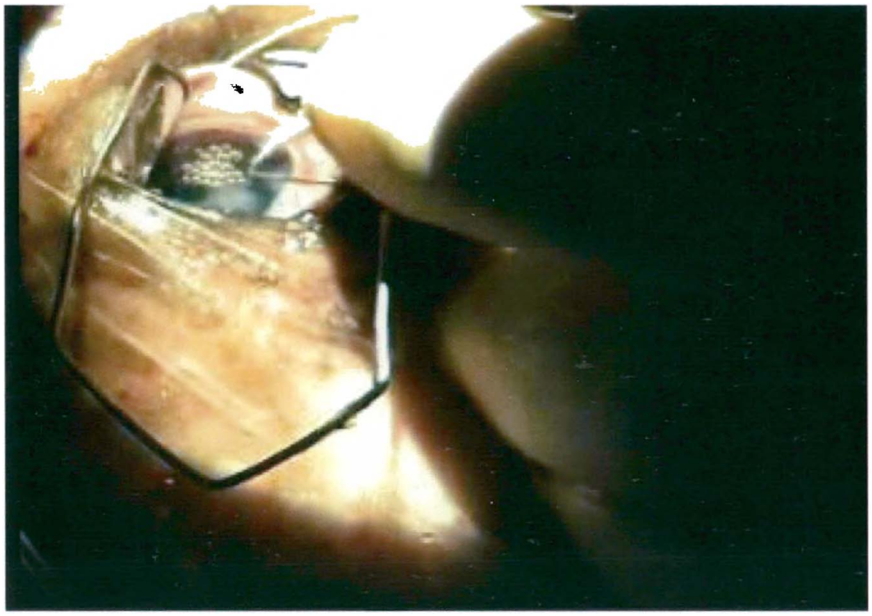

Fig No. 13: Aspiration of the emulsified lens matter.

the process of CCC. Intracameral flushing with 1:1000 epinephine diluted with BSS(balanced salt solution) was done to reverse the condition.

*Step V*

Hydrodissection was done for separation of lens cortex from the capsule.

*Step VI*

Phacoemulsification was done by the phaco-chop technique. The Nagahara chopper was inserted through the 3 o'clock port and was held in the left hand (Fig. 11). The phaco handle was held in the right hand, was inserted through the 12 o'clock position.

The chopping instrument was passed under the anterior capsule edge, hooking the lens or lens nucleus at the equator. The chopper is pulled towards the phaco tip, Manual energy was used to compress and fracture the nucleus (Fig. 12). The machine was set at ultrasound power of 60%, vacuum of 190 mm/Hg initially with a flow rate 30cc/min. The chopper was moved along the natural fibers of the lens, once the chopping process was completed, the lens matters were removed using the irrigation aspiration unit (Fig. 13) Ringer lactate along with 0.5ml heparin and 1 ml adrenaline were used as the irrigating fluid. The aspiration was done a flow rate of 22mm/min at a vacuum of 350mm/Hg.

*Step VII*

Throughout the procedure the cornea was intermittently wetted with normal saline to maintain the hydration and prevent drying (Fig. 14).

*StepVIII*

The corneal incision was now increased to 5.2 mm using a keratome (Fig.15).

*Step IX*

The intraocular lens to be placed in the capsular bag was now held with a lens forceps and placed into the capsular bag (Fig. 16). The leading haptic was first placed under the rhexis margin at 6 o'clock position and subsequently the trailing haptic was dialed in with a Sinskey hook ( Fig. 17).The intraocular lens used were rigid, of 33 diopters, 13.5mm diameter, and 6.50mm optic.

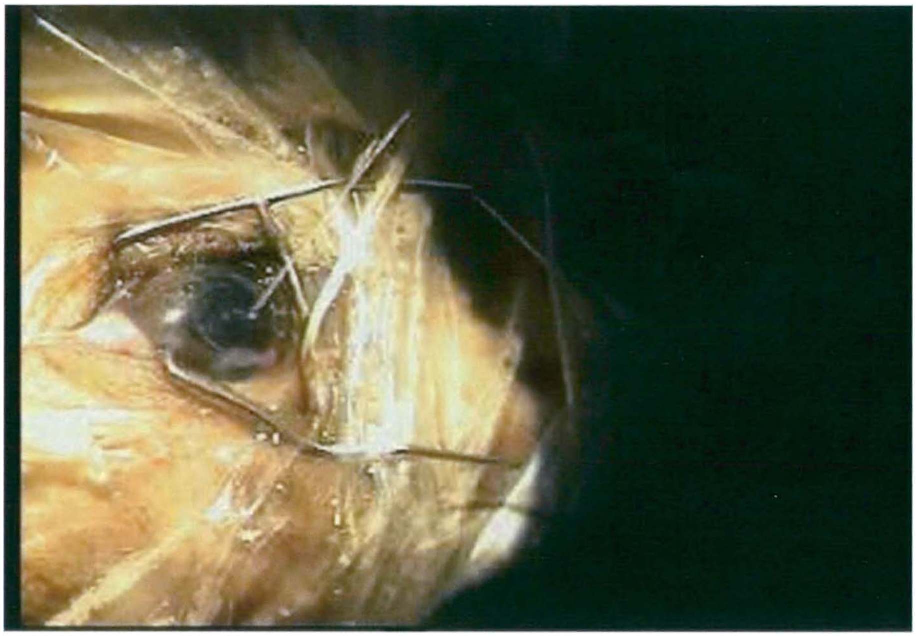

Fig No. 14: Intermittent wetting of the cornea with normal saline to prevent drying.

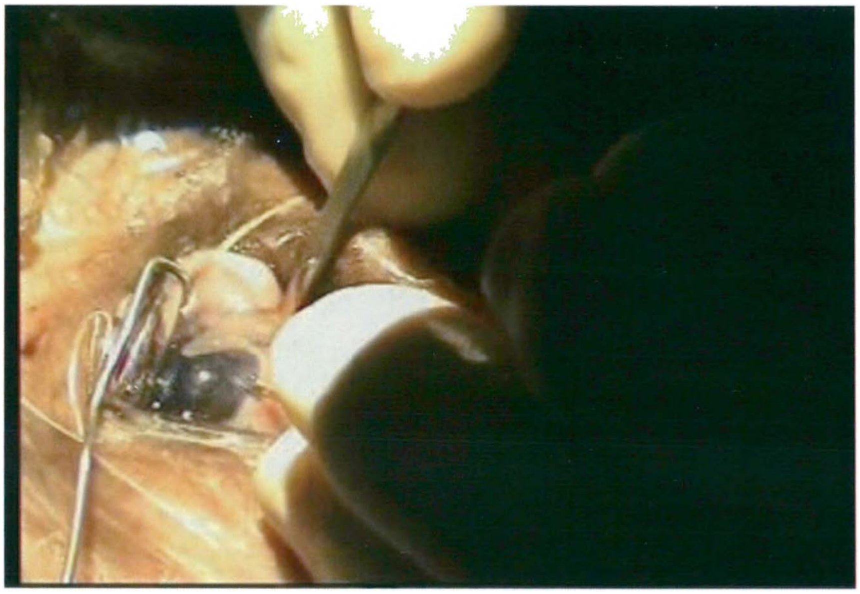

Fig No. 15: Corneal incision being expanded after lens removal.

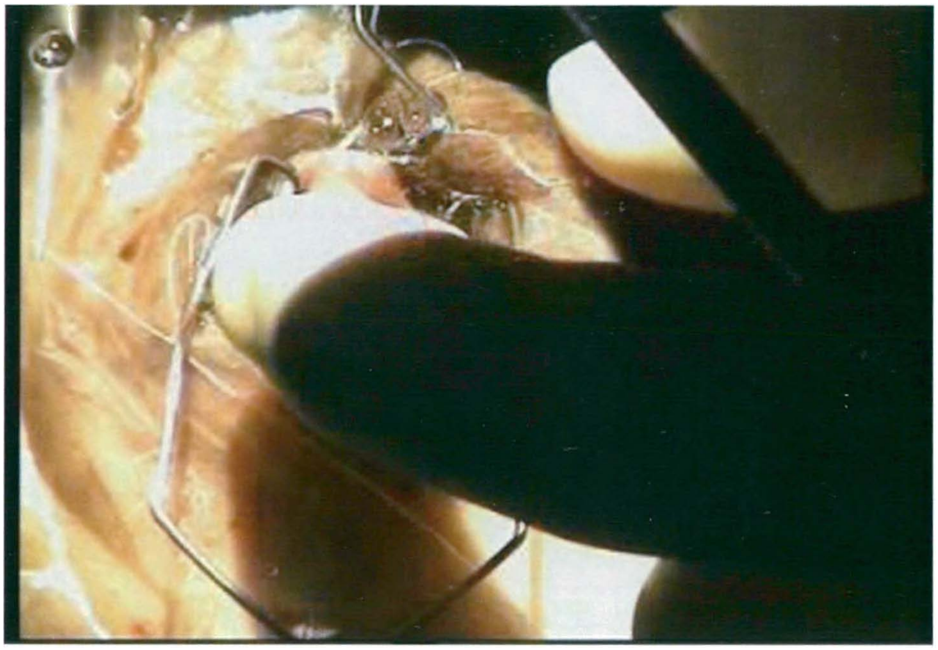

Fig No. 16 : Insertion of intraocular lens.

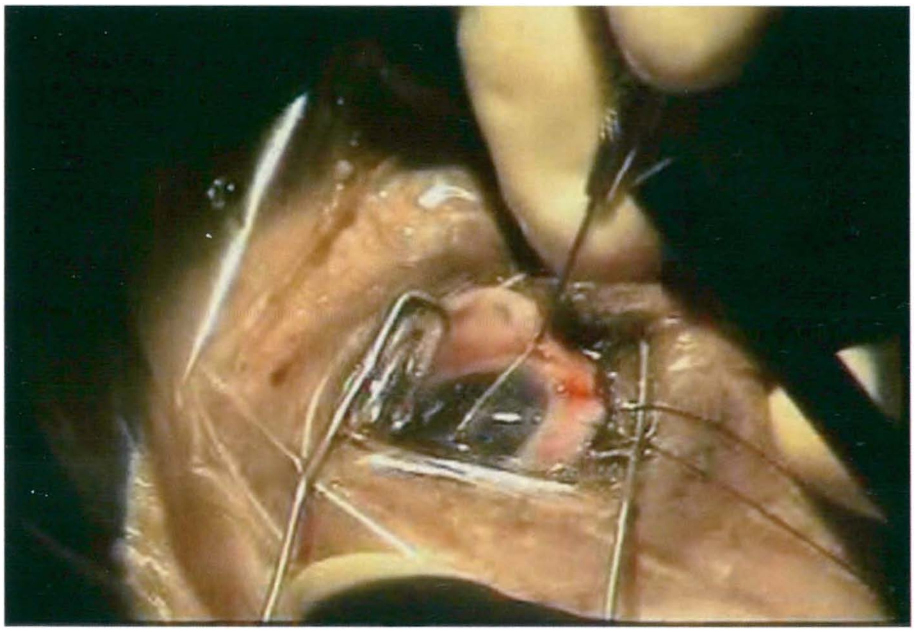

Fig No. 17 : The intraocular lens being positioned by dialing the trailing haptic using a Sinskey hook

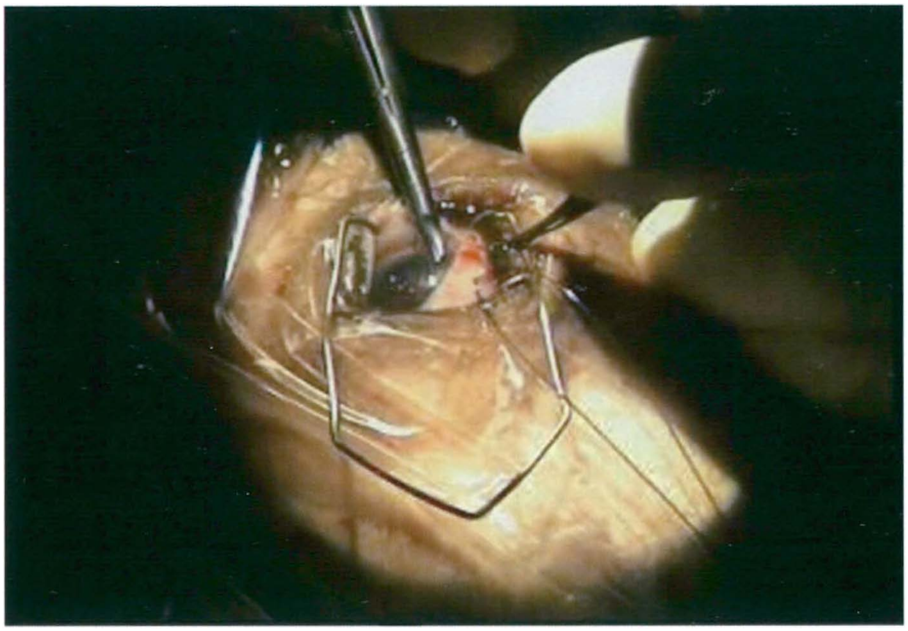

Fig No. 18: The corneal incision being closed with 10-0 mono filament nylon.

Fig No. 19 : Self inflected trauma was prevented by giving E-Collars postoperatively.

*Step X*

After completion of the procedure, the visco elastics was completely aspirated.

*Stcp XI*

The corneal incisions were closed with 10/0 monofilament nylon using two simple interrupted sutures (Fig. 18). The knots placed horizontally and were rotated within the wound. A 25g hypodermic needle was inserted in between sutures and a sufficient lactated ringer was injected to restore the volume of the anterior chamber. Intraocular pressure was measured 6 hrs after surgery and again 24 hrs postoperative.

All dogs were given Elizabethan-collars (E-Collar) for 1 month post surgery (Fig.19). Post operative medication was standard for cataract surgery in dogs.

**Post surgical management**

Topical Atropine Sulphate 1 % thrice daily for 15 days.

Topical prednisolone 1% four times daily for 1 month.

Topical Flubiprofen, four times daily for 1 month.

Topical chloremphenicol thrice daily 7 days.

Topical hypertonic saline ointment once daily for 10 days post operative.

**Systematic medication comprised of**

Inj. Enrofloxacin 10%, (Floxidin)®. Intervet India Ltd. For 7 days post operative Inj. Prednisolone (Prednisolone Acetate)® For 15 day post operative in gradual tapering doses.

Routine post operative evaluation was done ophthalmoscopically and clinically to observe the course of healing, the complications observed in the post operative period were registered for 1 month after surgery. The assessment for the return of functional vision was done by the following subjective tests.

**Cotton ball test**

A ball of cotton was let to drop from a height in front of the dog, and each dog was closely observed for its reaction and related eye movements. The normal eye was patched with black cloth.

**Obstacle test**

A black patch was put on the unoperated normal eye. An obstacle in form of a bucket, table etc. were placed in front, the dog was allowed to walk past the obstacle, and its movements were closely observed how well each dog could efficiently dodge the obstacle and walk past.

# RESULTS

# Results

**Model of cataract in rat**

Posterior capsular opacification, in varied degrees was detectable in all the rats ranging from 48 hrs after induction and by 15 days post induction, cataract had developed in all the rats.

**Histopathology of normal lens of rat.**

Well developed fibrocollagenous capsule containing lens protein; with parallel bar arrangements without cellular infiltration were observed. Protein bars appeared homogeneous eosinophilic without vacuole and degenerative changes. (Fig. 23)

**Histopathological features of the cataractous lens of rats.**

Well developed fibro collagenous capsule with a focal area showing infiltration of a few lymphocytes were observed. Lens protein appeared homogenous, vacuolar and with bubbly degenerative changes (Fig. 24).

**Model of cataract in dog**

The first sign of cataract development was seen in one of the normal dog (Fig. 20) on the 5$^{th}$ day after induction. Posterior cortical opacification was observed as the initial sign of cataract development (Fig. 21) and in rest of the dogs similar changes were observed ranging from day 7 to day 9. The cataract progression in all cases was initially slow but after an average of 60 days cataract formation was fast and by day 75 all dogs had developed cataract (Fig. 22).

**Histopathological features of normal lens of dog.**

Intact capsular membrane was seen with lamellar pattern of the lens protein which appeared structure homogeneous and eosinophilic. The thickness of the capsule varied with the region. The lens fibers showed small ball and socket interdigitation, and appeared as Y pattern sutures. (Fig.25).

**Histopathological features of the cataractous lens of dog**

Intact thick capsular membrane was seen with lamellar pattern of the lens protein which appeared fragmented and eosinophilic. Lens fibers appear swollen; A few small

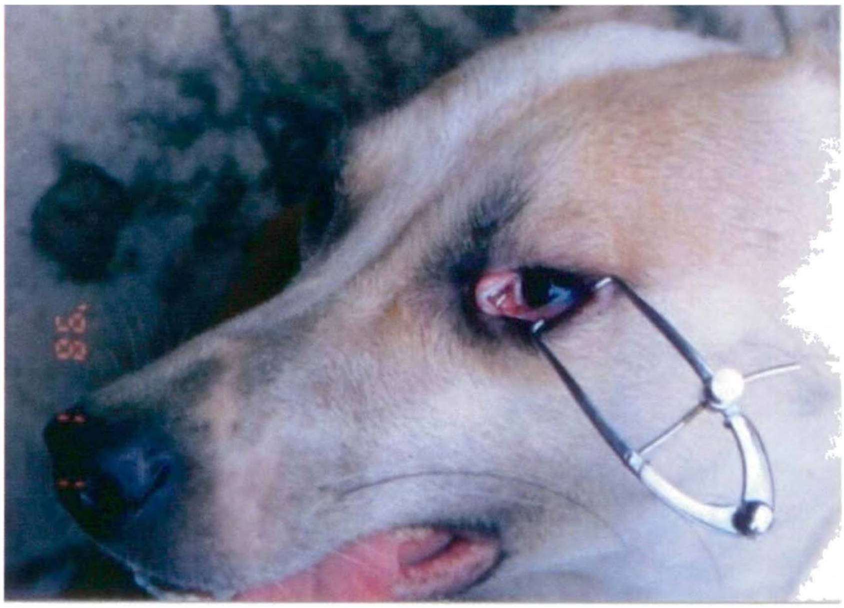

Fig No. 20 : Normal eye of dog prior to induction of cataract.

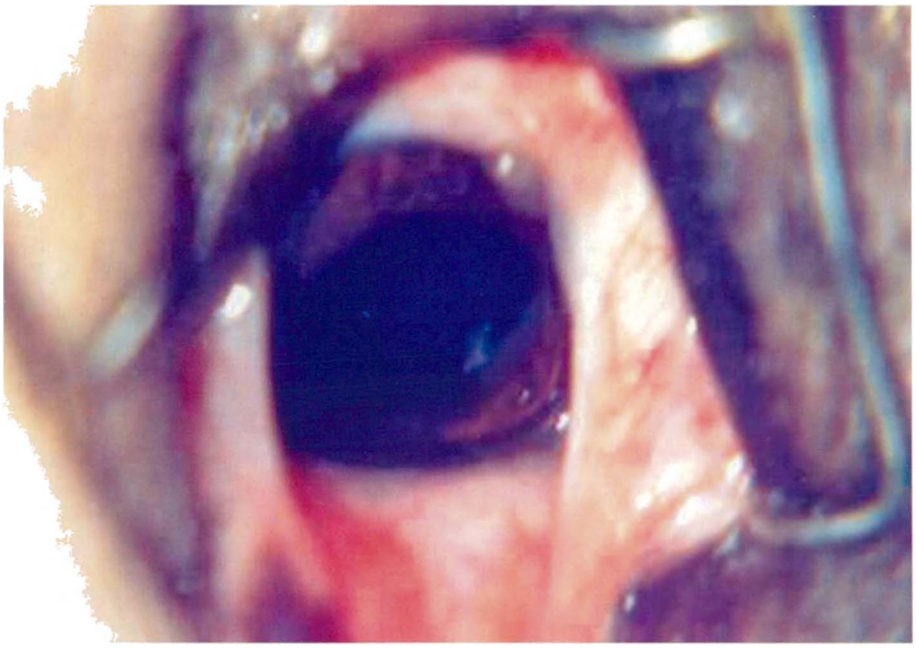

Fig No. 21 : Clinical evidence of initial signs of cataract development.

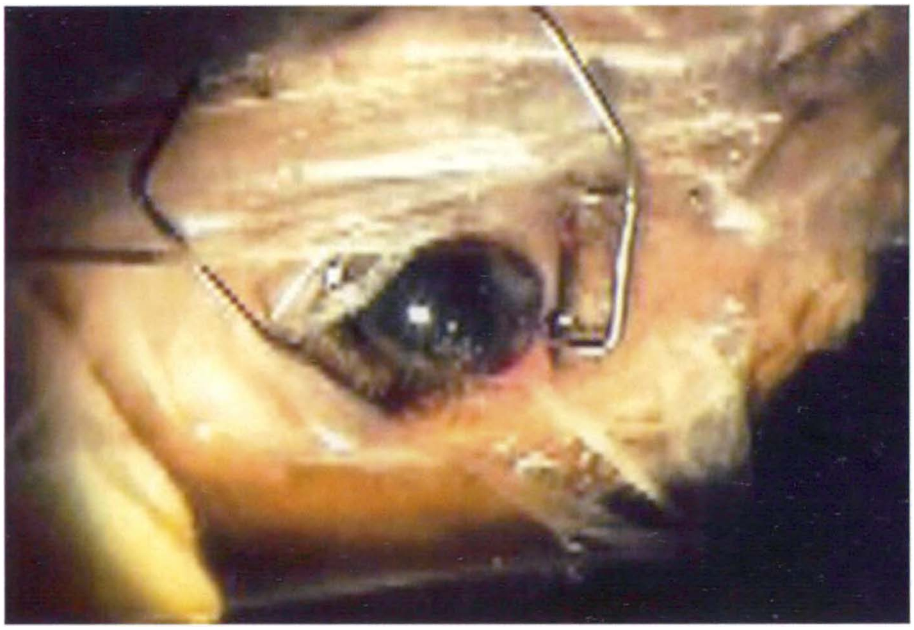

Fig No.  Fig. No. 22: Progressive stage of cataract development

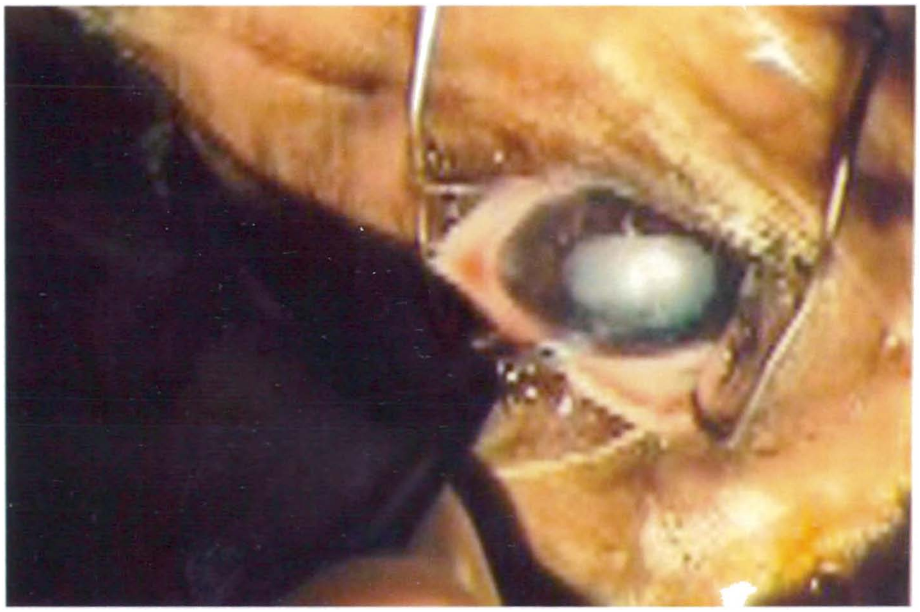

**Fig No. 23: Eye of dog showing complete cataract formation after induction.**

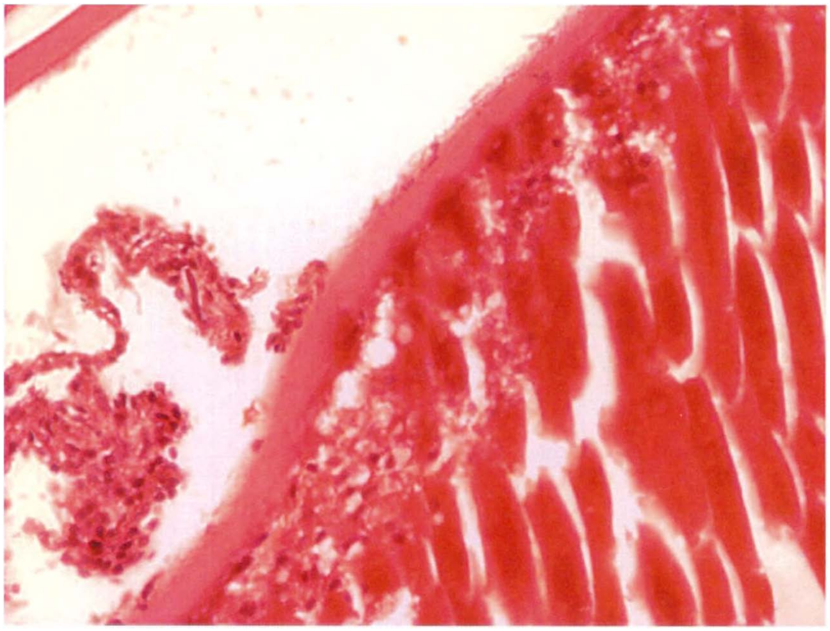

Fig No 24 : Normal lens of rat showing well developed fibrocollagenous capsule containing lens protein; with parallel bar arrangements without cellular infiltration.

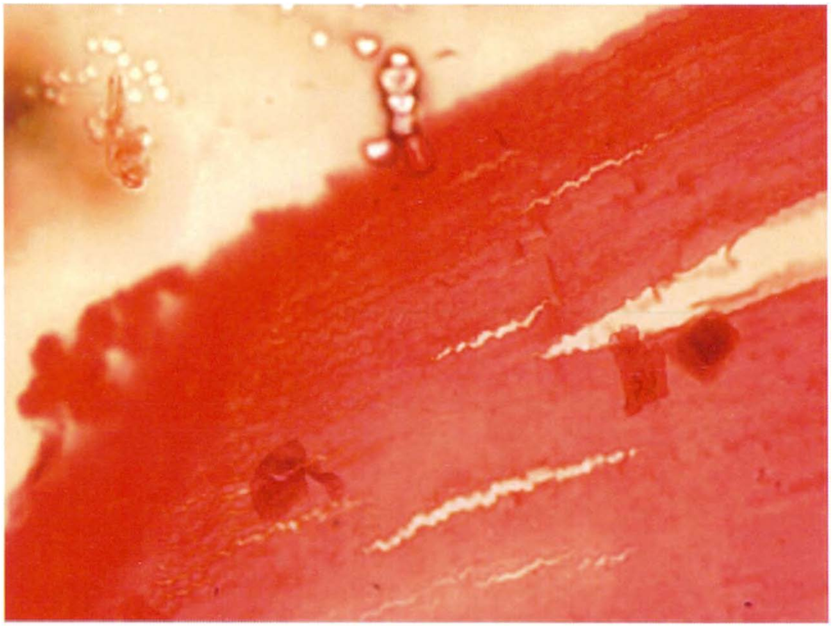

Fig No. 25: Cataractous lens of rat showing well developed fibro collagenous capsule with a focal area showing infiltration of a few lymphocytes

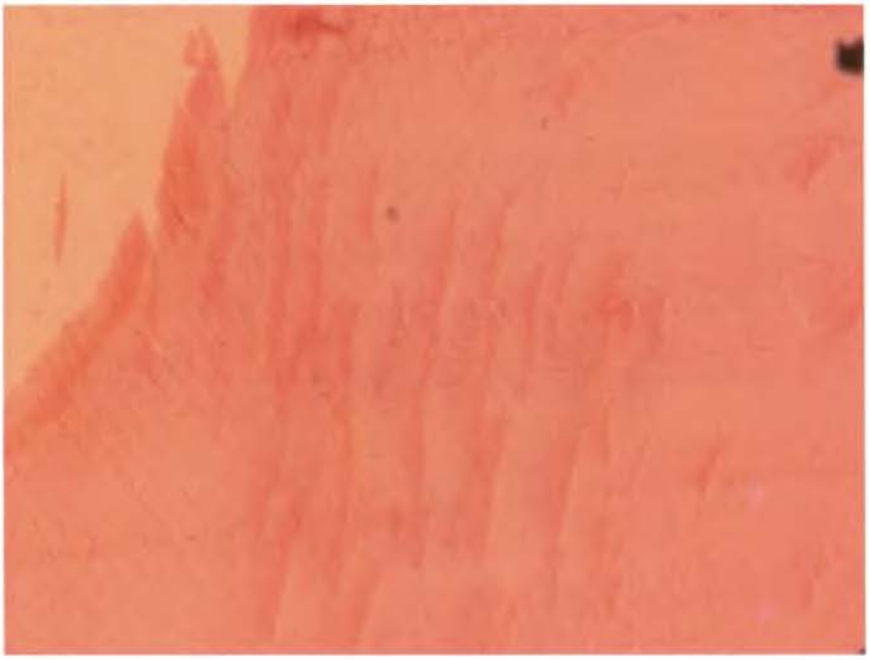

Fig No. 26: Normal lens of dog showing intact capsular membrane was seen with Lamellar pattern of the lens protein which appeared structure homogeneous and eosinophilic

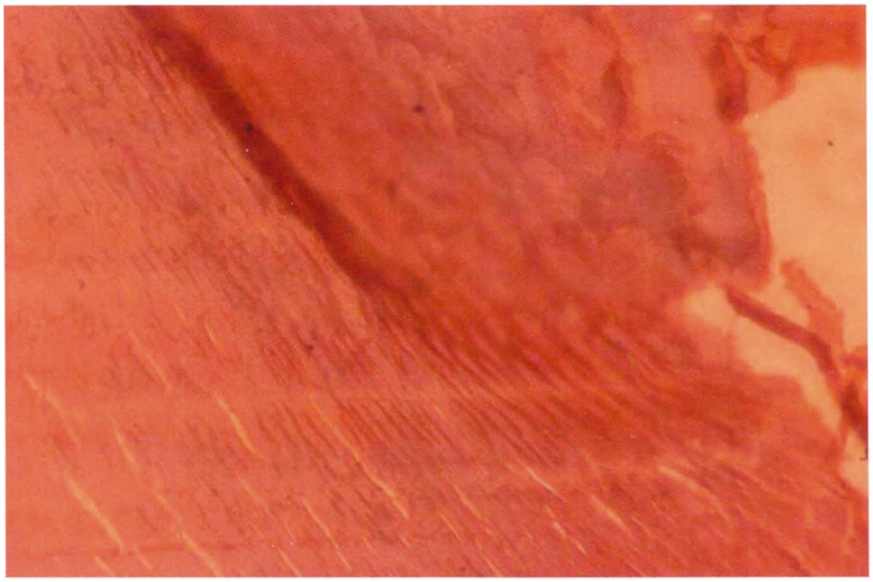

Fig No. 27: Cataractous lens of dog showing intact thick capsular membrane was seen with lamellar pattern of the lens protein which appeared fragmented and eosinophilic vacuolar structures were also seen. Cortical region with granulation and liquefaction of the lens fibers appear on the anterior lenticonus. (Fig.26)

**Result of preoperative evaluation of dogs for Phacoemulsification**

All dogs on preoperative examination were found healthy with normal blood sugar levels. Ophthalmologic examination prior to surgery showed all the dogs had clear cornea and were free from any other associated ocular disorder apart from cataract.
Satisfactory mydriasis was obtained in all the dogs scheduled for surgery and
the mean preoperative IOP (Intraocular pressure) recorded was 14.78+0.49 (Table.1).

**Anesthesia**

The anesthesia achieved with a combination of Xylazine, Ketamine and Diazepam was of required duration and depth to carry out the operation.
The mean IOP recorded after induction of anesthesia was 16.33+0.50(Table.1).

**Intraoperative Observations**

Placing the dogs in lateral recumbency gave good access to the left eyes. The sand bag proved very useful for securing the head in position while performing surgery.
The exposure of the globe in all the dogs was adequate; Lateral canthotomy successfully enhanced the surgical exposure to the globe. The eye positions were graded excellent in average cases, and good in three dogs. In one case it was interesting to note that the nictitating membrane had completely obstructed the cornea, it was retracted and full thickness suture was placed around the nictitans membrane cartilage and extended to and secured to a hemostat in the adjacent drape.

Entry into the anterior chamber through the corneal incision was quick and easy to perform, resulting in excellent exposure and visualization of the anterior chamber.
The anterior capsule was very well identified after staining with Trypan Blue, which eased the process of capsulorrhexis.

The continuous curvilinear capsulorrhexis (CCC) was performed successfully keeping the diameter of the CCC 1mm less than the diameter of the IOL to be placed subsequently. While performing CCC the anterior capsule was felt tough and elastic in consistency, so the Utrata forceps was used to assist in capsulorhexis and removal of the anterior capsule.

Intraoperative miosis was experienced in one dog and the condition was successfully reversed by treating with 1:1000 preservative free epinephrines that was previously added to the irrigation fluid. Thorough hydrodissection was done to prepare for the Chop technique and free rotation of the nucleus was obtained during the procedure.

The phacoemulsification was successfully accomplished using the Phaco Chop technique. The Nagahara Chopper was used to effectively break the lens along its natural fibers, as the chopper was pulled towards the phacotip manual energy was used to compress and fracture the nucleus. The phaco probe was used to emulsify the lens and the total matter was removed by aspiration, which was sufficient to attract pieces to the centrally held phaco tip. The time required to complete the phacoemulsification in each eye ranged between 30 to 40 seconds. Strong vacuum was achieved with total occlusion and a tight seal around the phaco tip.

Fibrin production in the aqueous humor was not remarkable in majority cases, with exception in one dog which had also experienced intraoperative miosis; the heparin in the irrigation fluid was effective in controlling the fibrin production. The viscoelastic used provided ideal cushion to the corneal endothelial while maintaining the shape of the globe. Intermittent flushing of the eye with normal saline prevented corneal drying (Fig.14). The complete lens matter could be removed. No major intraoperative complication was encountered during surgery. No cases of endopthalmitis were seen.

The intraocular lens was successfully placed into the capsular bag. In one dog decentralization of the lens and dislodgement into the anterior chamber was seen. It was successfully repositioned into the bag after several attempts. During surgery anesthesia was adequately maintained by ketamine @5mg/kg I/V initially followed by diazepam @0.02mg/kg I/V. At the conclusion of surgery the two sutures were sufficient to close the corneal wound.

**Post operative observation and follow-up.**

There was no immediate complication after surgery. All dogs had smooth recovery from anesthesia. Mean IOP at 6 hrs after surgery and 24 hrs after surgery were 18.72 + 0.42 and 15.11+0.42 respectively (Table.1).

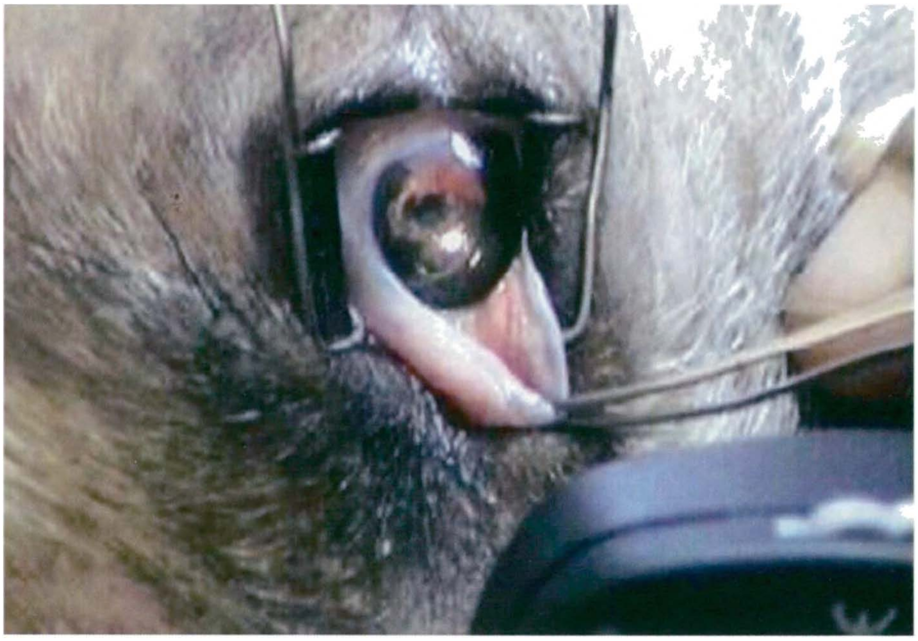

Fig No. 28: Anterior uveitis observed after one week of operation.

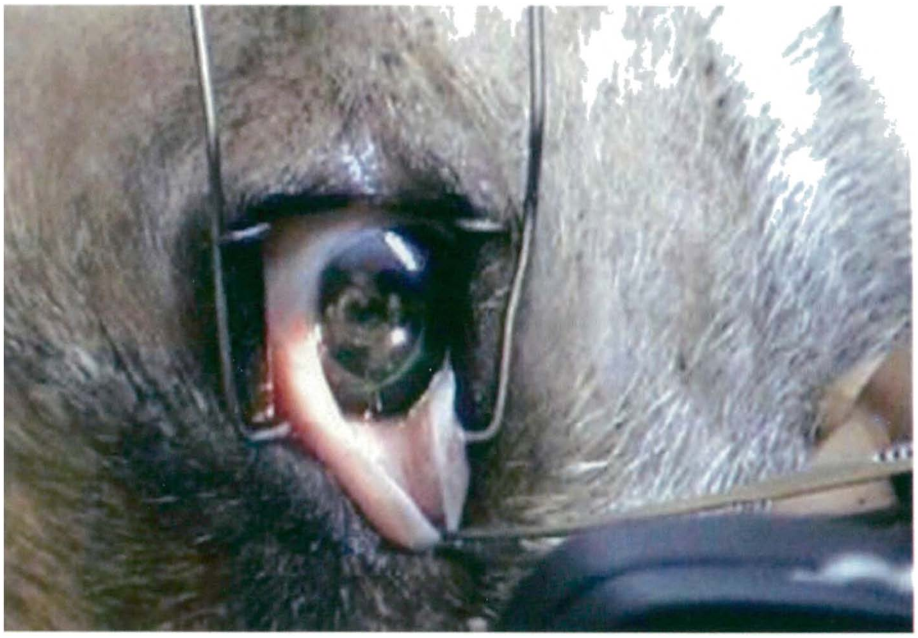

Fig No. 29: Anterior uveitis is less severe after two weeks of treatment

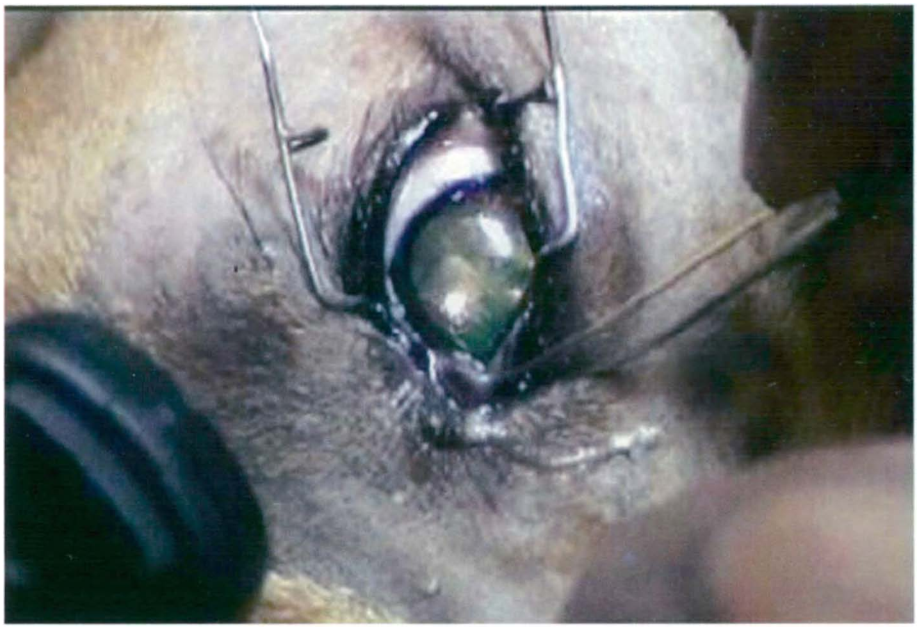

Fig No. 30: Anterior uveitis almost cured at third week postoperatively

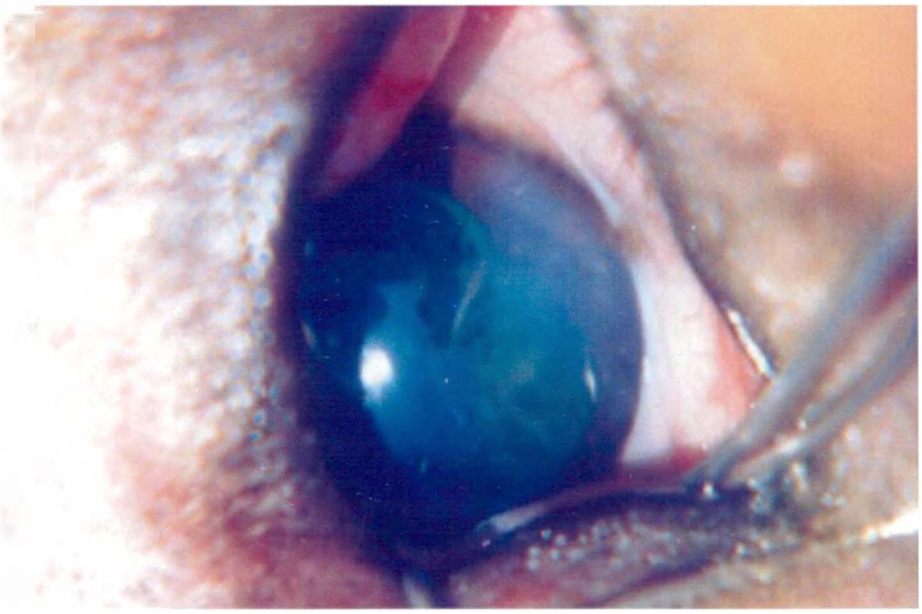

Fig No. 31: Restoration of vision with clear cornea and subsided uveitis as observed after one month postoperatively.

Operated eye of all dogs had developed corneal edema, treatment with anti-inflammatory drugs and hypertonic saline ophthalmic presentations successfully reduced the edema within 10 days in all cases. Uveitis had developed in varying degrees in all the cases (Fig.27). Vigorous anti-inflammatory treatment considerably reduced the condition, by the end of one month almost all dogs had recovered completely (Fig.28, 29). In one dog uvietis persisted and it later developed posterior synechia. In spite of appropriate medication no detectable improvement was observed clinically. Nevertheless the dog did not fail the vision test. There was no incidence of self trauma in the recovery period.

**Result for subjective test of vision**

Subjective tests for vision assessment revealed that effective ambulatory vision had been restored in all the dogs (Fig. 30). All dogs passed the obstacle test and reasonable response was obtained with the cotton ball test after one week postoperative. After one month the dogs showed good response to the test for vision assessment, they could find their food bowl and detect obstacles which were very much suggestive of restoration of vision.

Table: 1

Mean Intraocular pressure (IOP) at different time interval before and after induction of anesthesia.

| Pre-operative IOP (mmHg) | Post-anesthetic IOP(mmHg) | 6 hrs. Post-operative IOP(mmHg) | 24 hrs. Post-operative IOP(mmHg) |
|---|---|---|---|
| 14.78 + 0.49 | 16.33 + 0.50 | 18.89* + 0.42 | 15.11 + 0.42 |

*Significantly different from Pre-operative value ($P<0.01$)

# DISCUSSION

## Discussion

Over 20 million people are blinded by cataract globally. Reports of cross sectional population based studies reveal 75% people above 75 have vision impairment opacification (Klein *et al.,* 1998). Although there is paucity of literature regarding prevalence and incidence of cataracts in dogs, results of a preliminary studies show 50% of dog have opacity by 9.4 years and by 13.5 years, all dogs show signs of lens opacity (Williams *et al.,* 2004). As cataract prevalence increases with age, the challenges are to prevent or delay cataract formation and treat that which does occur. At present, phacoemulsification is considered the ideal technique for management of cataract that is visually significant. The important goals in modern cataract surgery are an astigmatic – free small incision with shorter rehabilitation time, CCC, phacoemulsification and in bag placement of an IOL. Further research in either therapeutic treatment of cataract or to shorten the steep learning curve of phacomulsification requires appropriate animal models which we have tried to accomplish in this study. Although the phaco chop technique has been adapted in dogs (Warren, 2004). This prospective study was also taken up to standardize this technique in existing setup under a different anesthetic regimen.

**Cataract model for study of cataract pathogenesis and for anticataract drug trial**

The lens is a fine tuning refractive media that helps to focus images on the retina, comprising 65% water and proteins (soluble and insoluble ) (Gelatt, 1991). The transparency of the lens capsule and cells are maintained as long as the relative dehydration is maintained by the active Na-K- ATPase pump. The histological features of the normal lens in the present study showed uniform lamellar arrangement of the lens protein, intact capsular membrane and the thickness of the membrane varied with region. This is similar to reports documented by Gelatt (1991), suggesting the normal capsular thickness in dogs is 8-12μm at the equator, 50-70μm anteriorly and only 2-4μm posteriorly (Gelatt, 1991).

Histological features of the cataractous lens showed swollen lens fibres, this could probably be the result of osmotic changes, caused due to disruption of the anterior capsule during induction leading to cataract formation. Presence of vacuoles and liquefaction of the lens protein, represent focal cell death, protein and liquid aggregation and insolubilization. The progressive swelling of the fibers results in plasma membrane rupture, cytoplasmic extrusion and destruction of the lens cells resulting in granulation and liquifaction (Gelatt, 1991). Hence from these results direct correlation between clinical assessment and microscopical changes associated with cataractous lens could be appreciated.

Clinically the slow progressive nature of the cataract formation observed in the present model may lend this model for trial of biochemical or pharmacological interventions that will maintain the transparency of the lens.

Among the animal models developed so far, selenite overdose cataract is an extremely rapid and convenient model of nuclear cataract for study of cataract pathogenesis. But selenite is cataractogenic only when administered to young rats before completion of the critical maturation period of the lens (16 days), and this cataract model develops within 4-6 days (Thomas *et al.,* 1997). Apart from general similarities to human cataract, a number of major dissimilarities are present. Contrary to human senile cataract, selenite cataract shows no higher molecular weight covalent aggregates or increased disulfide formation. It seems to be dominated by rapid calpain-induced proteolytic precipitation, while human senile cataract may be caused by oxidative stress over a long time period (Thomas *et al.,* 1997).

The model of cataract that has been developed in the study could be useful for study of cataract pathogenesis; since it is permanent in nature and develops over a period of 75 days. The progressive nature of the cataract so obtained in this study may be utilized for testing anticataract drug activity at different stages of cataract formation. This model may be suitable for studying molecular challenges that are responsible for increasing lens turbidity.

Initial attempt to standardize the model in rats resulted in rapid cataract formation; within 48 hrs of induction and complete cataract formation was observed within 15 days. In a similar study by Fagerholm and Philipson, (1979, a) experimental traumatic cataract was induced both in rats and rabbits, the lens changes were caused by injury to the anterior part of the lens and studied with Procian yellow as an extracellular tracer and by transmission electron microscopy at different time intervals after trauma. In rat lens a posterior subcapsular cataract developed within the first hour after trauma, whereas in the rabbit lens only one of 15 lenses developed opacity after one week in spite of large wound.

While establishing this technique for cataract induction in dogs the results differed in comparison to that of rat. The results in dogs were more predictable, and cataract had developed within 75 days. The nature of development was progressive, and the results of this study may be helpful for further studies on multiple mechanisms of cataract development. Other workers have also attempted to study on models of traumatic cataract in different species. Rafferty and Goosens, (1975) produced traumatic cataract in mouse model following a transcorneal needle injury. This is a cause of high incidence of traumatic cataract in human and frog. They found that this injury in mouse elicits a repair process whereby the damaged capsule is rapidly renewed and permanent lens opacity seldom occurs. The results are attributed to ultrastuctural differences between mouse and human lenses, such as presence or absence of dense bundles of microfilament and desmosomes are considered in relation to lens shape and tension and susceptibility to injury induced cataract.

In a separate study in order to shed some light on the origin of the cataract caused by various factors, traumatic cataract was experimentally induced in the lens of a Japanese monkey and electron microscopical studies were conducted, thus clinically opacity of the posterior subcapsular cortex was established. In the present study too posterior capsular opacity was observed in the traumatic model of cataract in dog. In the model of traumatic cataract created in monkey morphological changes showed an acceleration of water absorption of the lens fibers from an early stage and the increase in the number of mitrochondria in such swollen fibers may play an important role in the process of cataractogenesis (Katsume *et al.*, 1983).

Lipid peroxidation of lens lipids has been considered as one of the initial mechanisms of cataractogenesis (Babizhayev and Costa, 1994). This oxidative condition can be due in part to the decrease in antioxidant defences of the lens and surrounding tissues and fluids.

Ascorbic acid has been suggested to be a natural protector against photo oxidation of the eye tissues. Concentrations of ascorbic acid in aqueous humour are much higher than plasma concentration and may be responsible for the prevention of lens oxidation (Varma, 1991). Unlike primates and guinea pigs, dogs are able to synthesize ascorbic acid from uridine diphosphate glucose (Banhegyw *et al.,* 1997), this could be a possible explanation for the slow rate of cataract formation in dogs in the present study in comparison to the rate of cataract formation in rat.

In a study, the levels of enzymatic and nonenzymatic antioxidants in blood and aqueous humour of cataractous and noncataractous dogs were evaluated. Results showed decreased activity of antioxidants enzymes may constitute a risk factor for cataract development (Paulo *et al.,* 2004). From the results of such studies the protective factors for cataract formation in different species may be identified and used as a therapeutic tool for prevention of cataract in future. Canine models can serve as large animal models intermediate between mouse and man for both gene discovery and the development of novel cataract therapies (Hunter *et al.,* 2006).

**Cataract model for practice and standardization of phacoemulsification**

Among the surgical procedures employed for cataract operation, phacoemulsification yields the highest success rate, but it has a steep learning curve, which emphasizes the need for on hand practice in animal models. In this study a model of cataract has been created to practice phacoemulsification and to standardize the phaco chop technique in dogs under xylazine, ketamine and diazepam anesthesia

Since the learning curve for phacoemulsification is steep a number of training models have been devised for surgeons attempting to master phacoemulsification. Experience gathered by evaluating learning curve of residents learning phacoemulsification shows that average surgeon will require 50 cases before he/she is comfortable with the process. Vitreous presentation is high, about 50% over the initial cases and then drops to less than 5%. After 50 cases, vitreous presentation becomes less than 1%, other complications also show a declining tendency, with increasing number of cases handled (Csordas 1990; Coltier, 1992; Allison *et al.,* 1992; Cruz *et al.,* 1992; Martin and Burton, 2000).

Cataract has been created in postmortem pig's eyes using viscoelastic endothelial protection and formaldehyde-methanol mixture (Vinicus and Fabio, 2003) but the characteristic of the lens nucleus and capsule in these eyes are different from human eyes with senile cataract. In another attempt, cataract was induced in pigs eyes by placing them in micro oven for 9 seconds, although a hardened nucleus was obtained, it weakened the capsule and zonules (VanVreewijk and Pameyer, 1998).

Pandey *et al.* (2000) described a training model using human enucleated post mortem eyes by injecting paraformaldehyde and gluteraldehyde, although it simulates cataract in human, lack of availability and ethical reasons limited this method.

Cataract in goat's eyes was induced by injecting 20% formalin after performing CCC (Dada and Sindu, 2000). This method also had its drawback. Corneal clouding was observed due to endothelial toxicity of formalin.

Apart from wet lab training, uses of special devices have been reported for training of ocular surgery (Porrello *et al.,* 1999). Computer simulated phacoemulsification has also been experimented (Laurell *et al.,* 2004). These methods can give surgeons a false sense of security and the surgeon can be evaluated only objectively. Another major problem mentioned with the method is that the development of virtual reality applications is expensive and time consuming.

In view of the above, it is assumed that the best training model would be to work on live eyes. The practice of CCC is correlated to the fitness and elasticity of the anterior capsule. It is assumed that both age and end stage maturity has effects on the loss of thickness and elasticity of the anterior lens capsule (Fatma *et al.,* 2005). Dada *et al.* (2001) suggested that elasticity of the anterior capsule needs to be altered for practice of CCC. In the present study although the capsules were felt tough nevertheless CCC was performed and practiced with ease, the probable cause could be that consistency of anterior capsule in younger dogs was appropriate for performing CCC without major difficulty. But in other animal models developed to practice phacoemulsification it was opined that the elasticity of the capsule was very different from that of human and need to be altered (Hashimoto *et al.,* 2001). Sudan *et al.,* (2002), have altered the elasticity of anterior capsule of goats' eye by injecting 20% formalin (0.2ml), for Harding the nucleus and altering the anterior capsule in their animal model for teaching phacoemulsification.

The intra operative complications and operative insufficiencies are best encountered while working on live eyes. Complications due to excessive intra operative instrumentation or the benefits of the efficiency gained with practice in the initial cases could be appreciated with the live practice model. The reduction in the complications with subsequent cases and the return of vision, the ultimate assessment of the successful outcome of the procedure, can be best judged in clinical cases. Live models of cataract have been created in dog with 2, 6,disophenol at a dose of 30mg/kg subcutaneously (Martin, 1975). The major disadvantage of this model was that all cataracts developed in this study were transient in nature lasting from one to five days and extreme debilitation was encountered in the dogs with repeated administration of disophenol. Cataract was experimentally produced in orphaned puppies fed on commercial replacement for bitches' milk (Martin and Chambreau, 1982), but the opacities were mild and decreased with time. A study conducted to observe the effects of phacoemulsification and extra capsular lens removal on corneal thickness and endothelial cell density in the dog suggests that dog corneal endothelium responds to surgical trauma in a manner similar to man. It therefore represents a good animal model for study of corneal endothelial disease in man (Gwin *et al.,* 1983). With the permanent nature of the cataract obtained in this study, it is felt that this model can be used to study the progression and pathogenesis of traumatic cataract and it can serve as a unique model for on hand practice of cataract surgery.

**Criteria for patient selection for phacoemulsification**

Selection of patients for phacoemulsification can have profound effect on the outcome of the surgery. In this study selection of young dogs free from concurrent ocular disorders and elevated blood sugar contributed to favorable outcome of the study, similar reports suggests phacofragmentation surgery was significantly more successful in young dogs compared to aged dogs (Fatma *et al.,* 2005)

**Anesthetic regimen for phacoemulsification in dog**

General anesthesia is imperative for cataract surgery in dogs. Although reports suggest that most surgeons prefer systemic neuromuscular blocking agents, for cataract surgery in dogs, which significantly improves the procedure, by stabilizing the eye position (Dziezyc, 1990; Nassisse and Davidson, 1991; Young *et .al.,* 1991), in the present study good and appropriate eye position under ketamine, xylazine and diazepam anesthesia was observed.

The use of ketamine in ophthalmic surgery has been investigated. Ketamine combines analgesic and sleep producing effects with significant cardiovascular and respiratory depression. Reported literature on use of ketamine anesthesia in pediatric ophthalmic surgery state it seems to be the answer to the definite need for a safe and potent anesthetic, for the pediatric population (Raju, 1980). Cataract extraction under short acting anesthetic such as thiamylal sodium, has also been done in the past. But, major constraint was the rotation of the globe, which needed repeated correction (Gelatt, 1991; Hazra and Samanta, 1999). Cugini *et al.*, (1997), performed cataract surgery under ketamine induced sedation, and concluded that it did not influence IOP and enabled comfortable completion of surgery. In the present observation nonsignificant rise of IOP under ketamine anesthesia was recorded.

The use of xylazine along with ketamine may have helped to reduce the intraocular pressure along with improvement in pupillary size (Kilic and Unsaldi, 2005). Xylazine and diazepam may have contributed to relaxation of the extraocular muscles (Permikoff, 1967; Kilic and Unsaldi, 2005), together with sufficient retrobulbar block was sufficient to stabilize the eye, (Young *et al.*, 1991).

Pilot studies have been carried out to achieve analgesia during phacoemulsification by systemic infusion of lidocaine in dog (Smith *et al.*, 2004). In the present study, the analgesic properties of ketamine have helped to, ease the procedure and it was probably responsible for the absence of blepharospasm which is usually associated with ocular pain.

**Phaco chop technique**

Apart from routine preoperative preparations for cataract surgery, it is important to place the animals head in secure position to prevent any positional changes during surgery. The sand bags used to secure the head during surgery in the present study proved to be very useful and a low cost technique which could be easily prepared. Other ways to maintain the head in a secure position are the use of towels, water bottles, and alternative superior scheme can be vacuum bead filled U-shaped pack (Gelatt and Gelatt, 2001).

Appropriate preoperative and post operative medical treatment of cataract is essential for the overall success of the surgery. One of the objectives of preoperative medication for cataract surgery in general and phacosurgery in particular are mydriasis of the pupil to visualize the lens during surgery. Mydriasis observed in all the dogs with topical treatment with atropine Hcl and phenylephrine 10% was adequate to perform surgery. A combination of 2% homatropine and 10% phenylephrine Hcl injected subconjunctivally (0.1ml of each ) in normal and cataractous dogs 10 to 15 mints prior to surgery may also provide clinically effective mydriasis (Gelatt, 1991).

Among the three basic anatomic incisions used to gain entry into the anterior chamber, in this study the clear corneal incision was selected because it was quick and easy to perform, but one disadvantage was the opacification along the incision line (Gelatt, 1991). The other entry into the anterior chamber may be through the limbus and sclera. The anterior portion of the limbus should be selected for entry, the posterior linbus adjacent to this area is more vascular and should be avoided. Scleral incision into the anterior chamber in dogs is associated with hemorrhage from the scleral vasculature, as a result scleral entry into the anterior chamber is generally not recommended (Gelatt and and Gelatt 2001).

Once the anterior chamber is entered, intraocular pressure rapidly decreases, hence viscoelastics are used to maintain the anterior chamber, 2% Hydroxypropyl methylcellulose which is inexpensive and readily available with desirable biophysical properties are chosen for the purpose (Torngren *et al.*, 2000; Rainer *et al.*, 2006).

For appropriate application of CCC, which is very important for the success of phacofragmentation surgery, visualization of the anterior capsular was highly improved with the use of Trypan Blue. Similarly it is also important to keep the anterior capsule well identified and in sight throughout the procedure to avoid placing the phacoprobe above the capsule instead of under the leading edges (Warren, 2004). In the present study the visualization of the anterior capsule by staining with Trypan Blue was also enhanced and identification of the capsule throughout the procedure was well appreciated. The diameter of the capsulorrhexis (CCC) was made 1mm smaller than the diameter of IOL optic, for proper in the bag fixation of the lens (Gelatt and Gelatt, 2001).

The phaco chop method adopted for chopping the nucleus of the lens was introduced by Nagahara. The principle of this method involves chopping the lens with a second instrument, by applying chopping forces parallel to the natural planes of the lens lamellae, the nucleus can be cleaved. Studies have shown that in comparisons to four quadrant divide and conquer the phacochop technique uses less phaco time and energy (Hayashi *et al.,* 1994; Pirazzoli *et al.,* 1996; Debry *et al.,* 1998; Ram *et al.,* 1998; Wong *et al.,* 2000). This method was successfully adopted in this study, although translation of this method in veterinary patients have required some modifications with instrumentation considering that axial lens thickness in diabetic dogs increases between 8-11mm. So the human chopper of an average 2 mm needs to be modified (Warren, 2004). In the present study the available human chopper has been used successfully on canine patients, since all the dogs were young and non diabetic this could be a possible factor for the easy adaptation of human chopper in dogs. Strong vacuum of 350mm/Hg was required to hold the lens on the phacotip. Sufficient phacopower is requried to impale the lens without exerting too much downward pressure. If the phacotip is pushed too hard on the lens, posterior capsular rupture can occur (Nagahara, 2002).

**Intraoperative complications**

Common intraoperative complications include rupture of the posterior lens capsule, prolapse of vitreous into the capsular bag or anterior chamber (Williams *et al.,* 1996; Nasisse and Davidson 1999; Zahn and Kostin, 2001; Gilger, 2003) anterior capsular fibrosis, descements membrane tearing (from phaco needle), miosis, iris herniation through the incision, radial tears in the anterior capsule, displacement of lens fragments into vitreous cavity, posterior capsule opacification (PCO), cavitation bubbles (Glover and Constantinescu,1997; Nasisse and Davidson, 1999). Due to the prenatal development of the lens, the embryonic lens is already well developed and surrounded with anterior and posterior capsule, before the embryos immune system becomes organized. Hence following a trauma or tear in the anterior lens capsule results in mild iridocyclitis (Gelatt and Gelatt, 2001). Although the iridocyclitis was not very obvious clinically prior to surgery, but the presence in mild form was relevant in the present study due to trauma induced cataract. It is also known that entry into the anterior chamber causes the release of endogenous prostaglandins from the iris and anterior uveal tissue causing a breakdown of the blood aqueous barrier (BAB), increased levels of protein and fibrin in the aqueous humor. In our study aggressive preoperative treatment with anti-inflammatory agents from two days prior to surgery eliminated major intraoperative complications.

Intraoperative miosis was encountered in one dog, despite preoperative medication, miosis can occur spontaneously during surgery (Glover and Constantinescu, 1997). Similar to their suggestions, intracameral injection of 1:1000 epinephrine helped for reversal of the condition in the present study. As fibrin in the aqueous humor is undesirable, Ringers lactate was used in combination with epinephrine and heparine as irrigating fluid in the present study. Heparine at 0.5ml in 450ml Ringers lactate was sufficient to control the fibrin formation (Gelatt and Gelatt, 2001).

**Post operative complications**

Major post operative complications generally encountered during phacofragmentation and aspiration surgery were corneal wound dehiscence, aqueous leakage, corneal edema, (due to endothelial loss), uvietis, bacterial endopthalmitis, posterior capsular opafication, hypema, retinal detachment, ocular hypertension sometimes leading to glaucoma (Miller *et al.,* 1987; Dziezye, 1990; Glover and Constantinescu, 1997; Nassisse and Davidson, 1999 ), optic neuritis retinal haemmorhage and corneal lipidosis (Bagley and Lavach, 1994).

Post operative ocular hypertension is one of the complications arising after phacoemulsification (Patricia *et al.,* 1996; Miller *et al.,* 1997; Lilian *et al.,* 2000; Lannak, 2001; Sabine *et al.,* 2003). The mechanism of post operative IOP increase is not yet fully understood. Numerous studies have tried to explain the mechanisms by which acute intraocular pressure increases in first hours after surgery. The immediate increase was the result of a combination of rapid aqueous humor production and water tight wound (Rich *et al.,* 1974). The other possible hypothesis for increase in IOP include, trabecular meshwork swelling, aqueous outflow obstruction by zonular fragments, the action of viscoelastic agents, residual lens particles, inflammatory debris, soluble lens protein, pigment or viscous aqueous or vitreous plasmoid humor (Gormoz, 1962; Rich *et al.,* 1974; Berson *et al.,* 1983; Ruiz *et al.,* 1987; Gross *et al.,* 1988; Alpar *et al.,* 1988; Miller *et al.,* 1997). But a major reason for the post operative IOP increase seems to be the amount of the remaining viscoelastic agent at the end of surgery.

In the present study this could be the possible explanation for significant (P<0.01) increase in IOP at 6 hrs post operative and subsequent regression to normal values at 24 hrs. The clearance of the viscoelastic agent through the trabecular meshwork is believed to be dependent upon the viscosity and molecular weight of the used materials, so we assume that the lower molecular weight and less viscous biophysical properties of hydroxypropyle methyl cellulose may be the reason for quicker clearance from the trabecular meshwork. Similar findings of a study which compared the effects of hydroxyl propyl methylcellulose 2% and sodium chondriotin sulphate 4% and Sodium Hyluronate 3% on postoperative intraocular pressure, showed that Ocucoat caused less IOP increase in comparison to viscoat. The reason was explained by difference in their biophysical properties (Miller *et al.,* 1997; Rainer *et al.,* 2001).

A number of reports suggest high incidence and early onset of postoperative hypertension after cataract surgery and have advised the routine use of antiglaucoma medications in the first 12 hours after surgery (Patricia *et al.,* 1996; Lannek *et al.,* 2001; Sabine *et al.,* 2003). The return of IOP values to normal preoperative values within 24 hrs did not require the use of any antihypertensive drugs in this study. The increase in IOP was significant (p<0.01) after 6 hrs postoperative but none of the dogs showed alarming increase in IOP that required therapeutic intervention. Increasing age tends to narrow the iridocorneal angle in dogs, contributing to decrease in aqueous humor outflow, which may predispose hypertension (Ekestan and Torrang, 1995). Similar findings were reported by Lilian *et al.,* (2000), while evaluating changes in IOP after aqueous exchange with several commercial available ophthalmic viscosurgical devices. Another explanation of POH associated with increasing age could be partially explained by age related hardening of the lens, leading to increased duration of phacoemulsification, increased surgical trauma and lens debris produced during the procedure (Lannek, 2001). Since the consistency of the cataract obtained was hard, this could possibly contribute to the transient increase in intraocular pressure at 6 hrs. Considering that all the dogs in this study were of a relatively young age the uncompensated iridicorneal angle could be another possible explanation for return of IOP to normal values within 24 hrs.

Other post operative complications were corneal and focal edema in all the dogs. Additional trauma and thermal effects during phacoemulsification may cause local edema (Gwin *et al.*, 1983; Nassisse *et al.*, 1990; Nassisse and Davidson, 1999).

Surgical trauma is the most common stimulant of anterior uveitis following cataract surgery, the canine eye like the eye of most domestic animals reacts much more violently than the human eye after intraocular surgery (Gelatt, 1991). Post operative anterior uvietis was observed in all the dogs. Similar results were reported with 100% incidence of uvietis after phacoemulsification (Gelatt and Gelatt, 1991). Chronic postoperative uvietis following phacoemulsification has been reported to be most notable complication in humans and dogs (Gelatt, 1991; Davidson *et al.*, 1991). Post operative medical treatment was aimed at controlling uveitis, maintaining pupillary size. In one dog it failed to produce sufficient mydriasis and eventually posterior synechia developed. A miotic pupil usually accompanies uvietis and secondary posterior synechia can develop (Bagley and Lavach, 1994). All other dogs showed signs of improvement to treatment with hypertonic saline formulations and anti-inflammatory drugs and the above conditions were cured.

Elizabethan collars and other restraint devices are recommended to prevent self trauma during the first 4-8 weeks. Small animals tend to rub their eyes during the first 7 to 10 days, and immediately after instillation of the ophthalmic solutions. In our study too Elizabethan collars were effectively used to prevent self inflicted trauma.

**Successful outcome of phacoemulsification in dog**

Vision was restored in eyes of all the dogs, established by standard subjective tests for test of vision (Fatma, 2005).

# SUMMARY

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# CONCLUSION

**Summary & Conclusions**

Cataract, the condition resulting from opacity of the lens or its capsules, is a major cause of blindness in dogs. Studies on the prevalence and incidence of cataract have shown that the numbers of cataract cases in dogs are almost parallel to that in man.
A lot of studies have been carried out with cataract preventing /delaying drugs and enormous funds exhausted for the purpose no substantial outcome have been established.

Surgery still remains the effective treatment for cataract, in both medical as well as veterinary ophthalmology. It is unfortunate that in developing countries affordability is a constraint; moreover there are not enough surgeons to perform the procedure. Even in countries like U.K., many patients put on the waiting list, die before their turn comes. Considering this situation, it is felt that the challenges of cataract prevention are worth taking up. The need for appropriate animal models to study cataract pathogenesis and trial for cataract preventing drugs are definitely felt.

As far as surgery is concerned, history for cataract surgery has come a long way. The latest technique of phacoemulsification has been reported to yield the highest rate of success. Veterinary ophthalmologists all over the world are now switching over to phacoemulsification as a method of choice for cataract removal. The major drawbacks are the expenses of the machine and the steep learning curve. In human ophthalmology too considerable loss is incurred by inexperienced surgeons, therefore wet lab training is considered essential.

A number of animal models of cataract have been devised to practice phacoemulsification, but these are either cadaver eye models or the cataract produced were very transitory in nature and ultimately failed to simulate the experience of working on a live model. This study was aimed to produce a live model of cataract in dog to practice phacoemulsification, which could also be used to study cataract pathogenesis and for anti-catarct drug trials. This study was also aimed to standardize the technique of phacoemulsification in dog under ketamine and diazepam anesthesia.

Ten healthy rats free from concurrent ocular disorders were selected for cataract induction cataract was induced under xylazine and ketamine anesthesia by creating defect in the anterior capsule of the lens, cataract developed in all the rats by 15 days post-induction. The same method was used to induce cataract in dog, where the dogs developed cataract by 75 days post induction.

The phaco chop technique was applied for phacoemulsification and removal of catacatous lens from the established animal models. Standard preoperative preparations for cataract surgery were adhered to. A combination of xylazine, ketamine and diazepam with local retro bulbar block was done to anesthetize the dogs for surgery. The anesthesia was of adequate depth, the eye positioning was good. The phacoemuisification was done with the machine set at frequency 60% at a vacuum of 120mm/hg initially with a flow rate 28cc/min followed by 28cc/min at 190mm/hg. Aspiration was done at frequency of 60% and a flow rate of 22mm/min at a vacuum of 350mm/hg. No major intraoperative complications was encountered, excepting intraoperative miosis in one dog, the condition was appropriately taken care of.

Post operative medications, were standard for cataract surgery, all dogs were put on E-collars, for a period of one month postoperatively. Normal IOP was registered, after anesthesia and at 6hrs and 24hrs. No significant change in IOP was observed due to anesthesia. At 6hrs increase in IOP was significant which reached normal values again at 24hrs. Major postoperative complications registered were corneal edema, anterior uvietis in all cases. In one dog, posterior synechia developed which was refractory to treatment. The intensity of complications was seen to reduce with subsequent cases.

Subjective tests for vision, eg. Cotton ball test and obstacle test were used to detect the return of vision a month after surgery.

From the above studies the different observations made can be summarized as

1) The technique used to induce cataract was successful in creating cataract.

2) The difference in the time taken to develop cataract in rat and dog are worth noting, further studies with other species may be taken up.

3) Adequate eye ball fixation and depth was obtained with this anesthetic combination, anesthesia did not influence the IOP.

4) Intensity of complications reduced with subsequent cases.

5) Vision was restored in all the dogs.

**Conclusion**

A live animal model of cataract was successfully created in dog, which can be used for on hand practice of phacoemulsification and for the study of cataract pathogenesis. The phaco chop technique of phacoemulsification was successfully adapted in dog under xylazine, ketamine and diazepam anesthesia.

# FUTURE SCOPE OF RESEARCH

## Future scope of research

The present study provides scope for both basic and applied research, required for the much needed progress in lens research.

The following aspects can be looked into:

1. The molecular mechanism involved for development of cataract in this model can be studied and compared with the cataracts developed from other etiological factors for identification of new targets and design strategies for anticataract drug development.
2. Trial of potential molecules for their therapeutic value against cataract can be taken up using this model.
3. As this model provides opportunity to the surgeons to practice phacoemulsification, studies can be taken up to make it more suitable for the purpose.
4. Though the phaco chop technique adopted in the present study, proved to be very effective for cataract removal in dog, there is always scope for improvement. Different viscoelastics and lenses may be tried in this regard.
5. Further studies to reduce the postoperative complications encountered presently i.e.Uveitis, postoperative increase in IOP, Posterior capsular opacification, can be taken up.
6. SICS (Small incisional cataract surgery) i.e. techniques like Scleral tunneling can be appropriately modified for adaption in veterinary ophthalmic surgery to bring down the cost involvement.

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