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Original Research Article

Effect of Surgically Induced Astigmatism on Sutured and Sutureless Incisions Placed at Various Superior Locations after Phacoemulsification Cataract Surgery Performed for Age Related Cataracts

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ABSTRACT

Over the years cataract surgery has undergone & is undergoing continuous refinements as it is one of the most gratifying rehabilitative (and curative at the same time) procedure in the medical practice. But what has not changed over the period is association of postoperative astigmatism with cataract surgery & uphill task for ophthalmologists to minimize it. In recent years, the evolution of the cataract operation has involved a progressive decrease in size of the incision for the extraction of the degenerated crystalline lens. Practically we have manual small incision cataract surgery (MSICS), Coaxial Phacoemulsification, Micro-Coaxial Phacoemulsification and Bimanual Microincision cataract surgery (B-MICS) in our hand to give our patients best possible visual outcome in terms of lesser and lesser astigmatism. 120 patients were selected for this study and divided in six groups. Within each group, each surgical technique was kept nearly constant and patients requiring an intraoperative alteration in the techniques were omitted from the study. Postoperatively, only those cases were kept in the study that did not have any confounding factors like postoperative inflammation that could have a bearing on visual outcome and corneal astigmatism. Dosage of topical steroids was also kept constant (i.e. 4 times daily in 1st week, 3 times daily in 2nd week, and 2 times daily in 3rd week) post-operatively. All other possible factors were kept constant. Neither age nor sex proved to be statistically significant in either of 6 groups across the study.
All patients were examined pre-operatively and post-operatively (on day 1 and 7 and at 1 and 3 months) to note keratometric (K1and K2) values and to calculate preop. and postop. astigmatism. All data was carefully accumulated, arranged and assessed statistically to derive significant conclusions using appropriate statistical method.
In our study SIA was studied for evolution, stability and its magnitude in 6 study group:
Surgically induced astigmatism was calculated using SIA Calculator based on the method of Holladay et al i.e. converting the pre-operative and post-operative astigmatism values in their components at X axis and at Y axis. Then Cartesian - coordinates is converted into astigmatic vector form.

Key words: Astigmatism, Phacoemulsification, Cataract Surgery

INTRODUCTION

Cataract is defined anatomically as any lens opacity on or inside the lens, or functionally as only those lens opacities that interfere with vision. [1] It is the most prevalent visually disabling eye disease in

the world. Millions of people in the world are blind with cataract accounting for 50% of blindness by World Health Organization (WHO).

Cataract may be classified on the basis of development, etiology, location, shape, texture, colour, or degree of opacification. A patient with cataract complains of gradual diminution of vision, repeated change of glasses, monocular diplopia, diminished contrast sensitivity etc. Cataract progression cannot be prevented once it has developed. Medical management has not been proven conclusively to prevent, delay or reverse the development of cataract in adults. Surgical extraction of cataract is the treatment of choice.

Over the years cataract surgery has undergone & is undergoing continuous refinements. The task of keeping abreast of the dynamic changes in cataract surgery is nearly indescribable. [2] Due to the evolution in cataract surgery, the goal of surgery has changed from one of "Restoration of Sight" to that of "Early Restoration of Visual Acuity".

The visual rehabilitation improved drastically with intraocular lens (IOL) implantation but astigmatism induced by surgery limited optical results.

The most important variables for surgically induced astigmatism (SIA) in a patient are incision, its size, site, placement of sutures and type of suture material used.

In the present study an attempt was made to study & compare the effect of surgically induced astigmatism on sutured & sutureless incisions placed at various superior locations, after phacoemulsification cataract surgery performed for age related cataracts.

Aims and Objectives:

- Evaluation of surgically induced astigmatism and UCVA for distance in patients undergoing standard coaxial phacoemulsification through 2.8 mm sutureless triplanar clear corneal and 2.8mm limbal incision with foldable PCIOL implantation.
- Evaluation of surgically induced astigmatism and UCVA for distance in patients undergoing standard coaxial phacoemulsification through 2.8 mm sutureless triplanar clear corneal and limbal incisions followed by enlargement of wound to 5.5mm size to facilitate implantation of 5.25mm optic size PMMA PCIOL.
- Evaluation of surgically induced astigmatism and UCVA for distance in patients undergoing standard coaxial phacoemulsification through 2.8 mm sutureless triplanar clear corneal and limbal incisions followed by enlargement of wound to 5.5mm size to facilitate implantation of 5.25 mm optic size PMMA PCIOL, with subsequent closure of wound with one infinity suture.

MATERIALS AND METHODS

Type of study

A prospective randomized study to compare the surgically induced astigmatism after phacoemulsification surgery.

Patient selection

The target patient population was those visiting Ophthalmology Department of E.S.I. Hospital, Basaidarapur with visually significant age related cataract for phacoemulsification surgery.

Sample size

120 Patients were enrolled and had been divided into 6 groups randomly with 20 eyes in each group. All eyes had undergone standard phacoemulsification cataract surgery.

The patients were randomly allotted groups I to VI-

Group	Wound size	Wound placement (in mm)	Number of eyes (n)
I	2.8	Clear corneal sutureless (CCI 2.8)	20
II	2.8	Limbal sutureless (L 2.8)	20
III	5.5	Clear corneal sutureless (CCI 5.5)	20
IV	5.5	Limbal sutureless (L 5.5)	20
V	5.5	Clear corneal with sutures (CCI 5.5 S)	20
VI	5.5	Limbal with sutures (L 5.5 S)	20

Inclusion criteria

Patients having visually significant age related cataract with nuclei of grade I to grade III density (according to LOCS classification) with keratometric astigmatism of 2 diopter or less had been taken up for study.

Exclusion Criteria

A. Preoperative

i. Patients with irregular astigmatism.
ii. Patients with bioblique astigmatism
iii. Preoperative corneal opacity of such size and effect so as to hinder with proper assessment of the keratometer readings.
iv. Those patients who had undergone any pervious surgery on the eye to be operated.
v. Patients with systemic and local diseases capable of affecting wound healing e.g. diabetes mellitus, scurvy, immunocompromized states, connective tissue disorder, scleritis.
vi. Coexisting glaucoma.

B. Operative

i. Patients who undergone extension of incisions intraoperatively to facilitate the surgery.

C. Post Operative

ii. Patients who developed postoperative gaping of wound, wound leak, wound dehiscence.
iii. Patients who developed severe postoperative inflammation requiring prolonged and excessive use at corticosteroids than normal.
iv. Patients with inadequate follow up.

Ophthalmologic Evaluation

Preoperative

- Meticulous history taking was done to rule out exclusion criteria
- Uncorrected visual acuity (UCVA) and best corrected visual acuity (BCVA) measured by Snellen's visual acuity chart.
- Evaluation of anterior segment: Detailed evaluation of the anterior segment was done using oblique illumination and slit lamp examination.
- Fundus examination: A detailed fundus examination was performed wherever possible under full mydriasis by direct ophthalmoscope. A definitive sign in fundoscopy suggestive of glaucoma or other definitive pathology that affects visual function to be noted.
- Retinoscopy was done using a streak retinoscope wherever possible.
- Keratometry: Preoperative keratomatry to be performed on all patients using a Bausch and Laumb type keratometer to determine the corneal component of astigmatism if any.

This was done for

- Calculation of IOL Power
- Calculation of surgically induced astigmatism in an operated eye.

Postoperative keratometry was performed on all patients on

- Postoperative day 1
- Postoperative day 7
- Postoperative days 28 (1 month)
- Postoperative day 84 (3 months)

- Axial length calculation by 'A scan ultrasound biometry' (Nidek US 3300)
- IOL power calculation by SRK II (Sanders, Retzlaff & Kraff, 1988) [3] formula

P = A - 2.5L – 0.9 K where,

P = lens implant power to produce emmetropia

L = Axial length (mm)

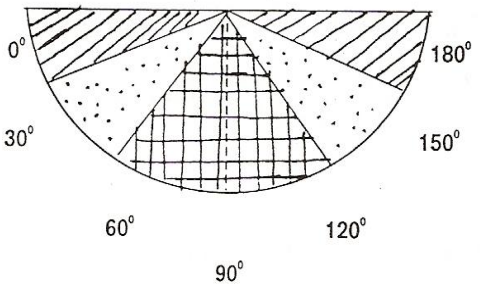
K = Average keratometer reading

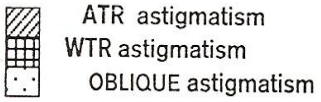
A = Specific lens constant for each type and/or manufacturer

IOL power was calculated to achieve emmetropia in every eye to be operated.

- Preoperative corneal astigmatism was analysed as follows:
  - Spherical (NIL)
  - WTR (With-the-rule): Steeper axis between 61 and 120 degrees.
  - ATR (Against-the-rule): Steeper axis between '0 to 30' and '150 to 180' degrees.

– Oblique: Steeper axis between '31 to 60' and '121 to 150' degrees.





Operative evaluation:

i. Operative technique used
ii. Incision parameters (length, location, site, shape, architecture shape, architecture)
iii. IOL inserted
iv. Intraoperative complications if any

Surgical Procedure

Informed consent of the patient was obtained prior to study. Maximum pupilliary dilation by 2% homatropine and 10% phenylephrine eye drops was achieved.

Akinesia and anesthesia was achieved by 6-7 ml peribulbar block (Xylocaine2% with 1:1,00,000 adrenaline (ASTRA-IDL) and 0.5% sensorcaine in equal quantities with 50 units of Hyaluronidase (HINIDASE)). The eye to be operated was prepped with 7% povidone-iodine solution and draped in the usual manner. Conjunctival-cul-de sac was cleaned with 5% povidone iodine solution. Steri-drape was placed to keep the lashes away from the operative field. Eye speculum inserted.

Two 1.1 mm side port incisions at 2 and 10 o'clock position were made with Microvitreoretinal (MVR) metal knife. Aqueous was replaced with 2% hydroxypropyl methyl cellulose. Approximately 5.5 mm size capsulorrhexis was fashioned using 26 Gauge cystotome, mounted on a syringe filled with hydroxypropyl methyl cellulose.

A triplanar valvular incision was created superiorly in the clear cornea or at the limbus using a 2.8 mm metal keratome. Cortical cleaving hydrodissection and hydrodilineation was done to ensure complete rotation of the nucleus. Nuclear disassembly in grade II & III cataracts was done by the stop and chop technique where as chip and flip technique was used in grade I cataracts. Bimanual irrigation and aspiration of remaining cortex was done. Implantation of foldable-hydrophilic acrylic posterior chamber IOL in the bag was done with the help of disposable injector through the same unenlarged incision. The wound was enlarged to 5.5mm using an appropriate sized metal knife and a rigid Polymethylmethacrylate (PMMA) of 5.25 mm optic size IOL implanted in the bag. The remaining viscoelastic was aspirated out by using bimanual irrigation and aspiration hand piece.

Closure of wound was ensured by stromal hydration of the main and side port incisions in eyes where the wound is to be left sutureless. In eyes where the wound is to be closed with sutures, an infinity suture of 10-0 monofilament …was used.

20 mg Gentamicin and 4 mg Dexamethasone was injected subconjuctivally after completion of the surgical procedure. Eye was dressed and bandaged for twenty four hours.

Post operative treatment

Following removal of dressing, patients were examined on slit –lamp to look for wound integrity, evidence of inflammation, centration of lens etc. Visual acuity recorded and keratometry done to find out the amount of SIA. Patients received topical prednisolone acetate 1% eye drops 4 to 6 times a day for six weeks in a tapering manner. Topical ciprofloxacin

0.3% eye drops 4 times a day for four weeks. Topical homatropine 2% eye drops twice daily for one week.

Follow up

Follow up was on day 1and 7 and at 1 and 3 months after surgery. Post-operatively, on each visit the patients were examined thoroughly on slit-lamp and their visual acuity and keratometry findings were recorded. Surgically induced astigmatism was calculated by SIA calculator on all follow-up visits.

OBSERVATIONS

A prospective randomized study was undertaken on 120 eyes of 120 patients with senile cataract, selected from the outpatient clinic of Eye Department of ESI Hospital Basaidarapur, for evaluation of postoperative corneal astigmatism after cataract surgery. Patients were divided into 6 groups of 20 each.

Data collected from the patients is presented in the following pages:

Table 1: Age and Sex distribution of patients in Group I (CCI 2.8)

Age Group(yrs)	No. of Patients (%)	Males(%)	Females(%)
45-50	5(25%)	4(20%)	1(5%)
51-55	6(30%)	2(10%)	4(20%)
56-60	5(25%)	3(15%)	2(10%)
61-65	2(10%)	1(5%)	1(5%)
66-70	2(10%)	0(0%)	2(10%)
Total	20(100%)	10(50%)	10(50%)

Age of the patient in group I ranged from 45 to 68 years with a mean age of 50.45± 7.78years (Table 1).

Table 2: Age and sex distribution of patients in Group II (L 2.8)

Age Group(yrs)	No. of Patients(%)	Males(%)	Females(%)
45-50	4(20%)	2(10%)	2(10%)
51-55	5(25%)	4(20%)	1(5%)
56-60	4(20%)	1(5%)	3(15%)
61-65	3(15%)	1(5%)	2(10%)
66-70	4(20%)	3(15%)	1(5%)
Total	20(100%)	11(55%)	9(45%)

Age of patients in Group II ranged from 45 to 68 years with an average age of 57.15± 7.44 years (Table 2).

Table 3: Age and sex distribution of patients in Group III (CCI 5.5)

Age Group(yrs)	No. of Patients(%)	Males(%)	Females(%)
45-50	4(20%)	3(15%)	1(5%)
51-55	4(20%)	3(15%)	1(5%)
56-60	4(20%)	2(10%)	2(10%)
61-65	4(20%)	1(5%)	3(15%)
66-70	4(20%)	2(10%)	2(10%)
Total	20(100%)	11(55%)	9(45%)

Age of patients in group III ranged from 45 years to 68 years with a mean age of 58.05± 7.16 years (Table 3).

Table 4: Age and sex distribution of patients in Group IV (L 5.5)

Age Group(yrs)	No. of Patients(%)	Males(%)	Females(%)
45-50	6(30%)	2(10%)	4(20%)
51-55	5(30%)	4(20%)	1(5%)
56-60	3(15%)	2(10%)	1(5%)
61-65	4(20%)	2(10%)	2(10%)
66-70	2(10%)	1(5%)	1(5%)
Total	20(100%)	11(55%)	9(45%)

Age of patients in group IV ranged from 46 years to 70 years with a mean age of 55.70± 7.64 years (Table 4).

Table 5: Age and sex distribution of patients in Group V (CCI 5.5 SUTURED)

Age Group(yrs)	No. of Patients(%)	Males(%)	Females(%)
45-50	3(15%)	1(5%)	2(10%)
51-55	5(25%)	2(10%)	3(15%)
56-60	4(20%)	2(10%)	2(10%)
61-65	2(10%)	1(5%)	1(5%)
66-70	6(30%)	5(25%)	1(5%)
Total	20(100%)	11(55%)	9(45%)

Age of patients in group V ranged from 45 years to 69 years with a mean age of 58.50± 7.34 years (Table 5).

Table 6: Age and sex distribution of patients in Group VI (L 5.5 SUTURED)

Age Group(yrs)	No. of Patients(%)	Males(%)	Females(%)
45-50	4(20%)	2(10%)	2(10%)
51-55	5(20%)	3(15%)	2(10%)
56-60	4(20%)	2(10%)	2(10%)
61-65	5(25%)	2()	3(15%)
66-70	2(10%)	1(5%)	1(5%)
Total	20(100%)	10(50%)	10(50%)

Age of patients in group VI ranged from 45 years to 68 years with a mean age of 57.15± 6.66 years (Table 6, Graph 6a, 6b).

Age distribution of patients was not statistically significant for any of 6 groups.

Total numbers of males in the study were 64 (53.33%) as compared to the total number of females (46.66%).

PREOPERATIVE OBSERVATIONS:

(A) Distribution of patients according to Pre-operative BCVA:

Table 7: Distribution of patients according to Pre-operative BCVA

Pre-op BCVA	Gp I(%)	Gp II(%)	Gp III(%)	Gp IV(%)	Gp V(%)	Gp VI(%)
<3/60	2(10%)	2(10%)	1(5%)	2(10%)	4(20%)	3(15%)
3/60 - <6/60	7(35%)	5(25%)	6(30%)	7(35%)	5(25%)	5(5%)
6/60 - <6/36	6(30%)	7(35%)	4(20%)	6(30%)	7(35%)	7(35%)
6/36 - <6/24	3(15%)	3(15%)	5(25%)	2(10%)	2(10%)	2(10%)
6/24 - <6/18	3(15%)	2(10%)	2(10%)	2(10%)	1(5%)	1(5%)
>6/18	1(5%)	1(5%)	2(10%)	1(5%)	1(5%)	2(10%)

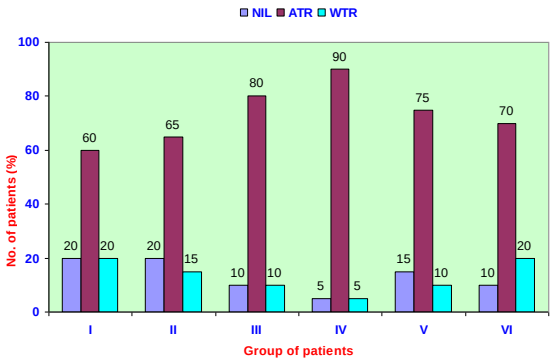
In group I, III and IV number of patients with a visual acuity of 3/60 to <6/60 were found to be the maximum. In group II, V and VI number of patients with a visual acuity of 6/60 to <6/36 were found to be the maximum. Best recorded visual acuity in all groups was found to be 6/18. The distribution was not statistically significant.

(B) Distribution of axis of Pre-operative corneal astigmatism in patients:

Table 8: Distribution of Pre-operative corneal astigmatism:

Type of astigmatism	Gp I(%)	Gp II(%)	Gp III(%)	Gp IV(%)	Gp V(%)	Gp VI(%)
NIL	4(20%)	4(20%)	2(10%)	1(5%)	3(15%)	2(10%)
WTR	4(20%)	3(15%)	2(10%)	1(5%)	2(10%)	4(20%)
ATR	12(60%)	13(65%)	16(80%)	18(90%)	15(75%)	14(70%)
Oblique	0	0	0	0	0	0

16 eyes out of 120 studied i.e. 13.33% of eyes did not have any pre-operative corneal astigmatism. 88 eyes out of 120 studied i.e.73.33 % of eyes studied had a pre-existing ATR astigmatism while the remaining 16 eyes of 120 studied i.e. 13.33% of eyes had a pre-existing WTR astigmatism (Table 8, Graph 1).



Graph 1: Distribution of Pre-operative corneal astigmatism in patients

POST-OPERATIVE OBSERVATIONS:

(1) Distribution of axis of astigmatism:

(A) 1st post-operative day:

Table 9: Distribution of axis of postoperative astigmatism on day 1, in various groups.

Type of astigmatism	Gp I(%)	Gp II(%)	Gp III(%)	Gp IV(%)	Gp V(%)	Gp VI(%)
NIL	0	0	0	1(5%)	0	0
WTR	7(35%)	6(30%)	4(20%)	6(30%)	14(70%)	11(55%)
ATR	13(65%)	14(70%)	16(80%)	13(65%)	6(30%)	9(45%)
Oblique	0	0	0	0	0	0

In group I on 1st post-operative day, 65% of patients had ATR astigmatism, 35% had WTR astigmatism.

In group II on 1st post-operative day, 70% of the patients had ATR astigmatism. 30% of the patients had WTR astigmatism.

In group III on the 1st post-operative day, 80% of the patients had ATR astigmatism. 20% of the patients had WTR astigmatism.

In group IV on 1st post-operative day, 65% of patients had ATR astigmatism, 30% had WTR astigmatism, while only 5 %of the patients did not have any astigmatism.

In groupV on 1st post-operative day, 30% of patients had an ATR astigmatism, 70% had WTR astigmatism.

In group VI on 1st post-operative day, 45% of patients had ATR astigmatism, 55% had WTR astigmatism.

(B) 7th post-operative day:

Table 10: Distribution of axis of postoperative astigmatism on day 7, in various groups.

Type of astigmatism	Gp I(%)	Gp II(%)	Gp III(%)	Gp IV(%)	Gp V(%)	Gp VI(%)
NIL	0	0	0	0	0	0
WTR	5(25%)	6(30%)	4(20%)	7(35%)	15(75%)	12(60%)
ATR	15(75%)	14(70%)	16(80%)	13(65%)	5(25%)	8(40%)
Oblique	0	0	0	0	0	0

In group I on 1st post-operative day, 75% of patients had ATR astigmatism, 25% had WTR astigmatism.

In group II on 1st post-operative day, 70% of the patients had ATR astigmatism. 30% of the patients had WTR astigmatism.

In group lll on the 1st post-operative day, 80% of the patients had ATR astigmatism. 20% of the patients had WTR astigmatism.

In group IV on 1st post-operative day, 65% of patients had ATR astigmatism, 35% had WTR astigmatism.

In group V on 1st post-operative day, 25% of patients had ATR astigmatism, 75% had WTR astigmatism.

In group VI on 1st post-operative day, 40% of patients had ATR astigmatism, 60% had WTR astigmatism.

(C) 1 Months follow-up:

Table 11: Distribution of axis of postoperative astigmatism at 1 month.

Type of astigmatism	Gp I(%)	Gp II(%)	Gp III(%)	Gp IV(%)	Gp V(%)	Gp VI(%)
NIL	2(10%)	0	0	0	0	0
WTR	3(15%)	4(20%)	3(15%)	5(25%)	12(60%)	9(45%)
ATR	15(75%)	16(80%)	17(85%)	15(75%)	8(40%)	11(55%)
Oblique	0	0	0	0	0	0

In group I on 1st post-operative day, 75% of patients had ATR astigmatism, 15% had WTR astigmatism. While only 10 %of the patients did not have any astigmatism.

In group II on 1st post-operative day, 80% of the patients had ATR astigmatism. 20% of the patients had WTR astigmatism.

In group III on the 1st post-operative day, 85% of the patients had ATR astigmatism. 15% of the patients had WTR astigmatism.

In group IV on 1st post-operative day, 75% of patients had an ATR astigmatism, 25% had WTR astigmatism.

In group V on 1st post-operative day, 40% of patients had ATR astigmatism, 60% had WTR astigmatism.

In group VI on 1st post-operative day, 55% of patients had ATR astigmatism, 45% had WTR astigmatism.

(D) 3 Months follow-up:

Table 12: Distribution of axis of postoperative astigmatism at 3 months.

Type of astigmatism	Gp I(%)	Gp II(%)	Gp III(%)	Gp IV(%)	Gp V(%)	Gp VI(%)
NIL	2(10%)	0	0	0	0	0
WTR	2(10%)	2(10%)	3(15%)	2(10%)	8(40%)	5(25%)
ATR	16(80%)	18(90%)	17(85%)	18(90%)	12(60%)	15(75%)
Oblique	0	0	0	0	0	0

In group I on 1st post-operative day, 80% of patients had ATR astigmatism, 10% had WTR astigmatism. While only10 %of the patients did not have any astigmatism.

In group II on 1st post-operative day, 90% of the patients had ATR astigmatism. 10% of the patients had WTR astigmatism.

In group III on the 1st post-operative day, 85% of the patients had ATR astigmatism. 15% of the patients had WTR astigmatism.

In group IV on 1st post-operative day, 90% of patients had ATR astigmatism, 10% had WTR astigmatism.

In group V on 1st post-operative day, 60% of patients had ATR astigmatism, 40% had WTR astigmatism.

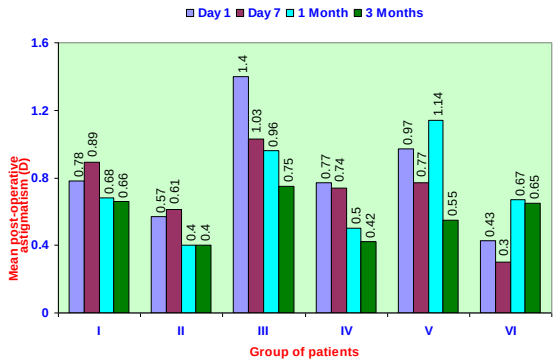
In group VI on 1st post-operative day, 75% of patients had ATR astigmatism, 45% had WTR astigmatism.

Distribution of average pre-op and average post-op astigmatism:

In group I the mean pre-op astigmatism was 0.40± 0.82 D. Postoperative corneal astigmatism values in Gp. I had a mean value of 0.78± 0.92 D on 1st postoperative day, 0.89± 1.01 D on 7th post-operative day, 0.68 ± 0.84 D at 1 month follow up and 0.66 ± 0.83 D at 3 months follow up (Graph 2).

In group II the mean pre-op astigmatism was 0.31± 0.56 D. Postoperative corneal astigmatism values in Gp. II had a mean value of 0.57 ± 0.92 D on 1st postoperative day, 0.61 ± 1.04 on 7th post-operative day, 0.40 ± 0.83 D at 1 month follow up and 0.40 ± 0.54 D at 3 months follow up (Graph 2).

In group III the mean pre-op astigmatism was 0.66± 0.67 D. Postoperative corneal astigmatism values in Gp.III had a mean value of 1.40 ± 1.04 D on 1st postoperative day, 1.03 ± 1.01 D on 7th post-operative day, 0.96 ± 0.84 D at 1 month follow up and 0.75 ± 0.63 D at 3 months follow up (Graph 2).



Graph 2: Bar graph showing distribution of mean post-operative astigmatism in different groups at various follow-up periods

In group IV the mean pre-op astigmatism was 0.71± 0.55 D. Postoperative corneal astigmatism values in Gp. IV had a mean value of 0.77 ± 0.92 D on 1st postoperative day, 0.74 ± 0.88 D on 7th post-operative day, 0.50 ± 0.58 D at 1 month follow up and 0.42 ± 0.44 D at 3 months follow up (Graph 2).

In group V the mean pre-op astigmatism was 0.54±0.56D. Postoperative corneal astigmatism values in Gp. V had a mean value of 0.97±0.1.13 D on 1st postoperative day, 0.77±1.33 D on 7th post-operative day, 1.14±1.07 D at 1 month follow up and 0.55 ± 0.73 D at 3 months follow up (Graph 2).

In group VI the mean pre-op astigmatism was 0.34±66 D. Postoperative corneal astigmatism values in Gp. VI had a mean value of 0.43±1.83 D on 1st postoperative day, 0.30±1.62 D on 7th post-operative day, 0.67± 0.91D at 1 month follow up and 0.65± 0.41 D at 3 months follow up (Graph 2).

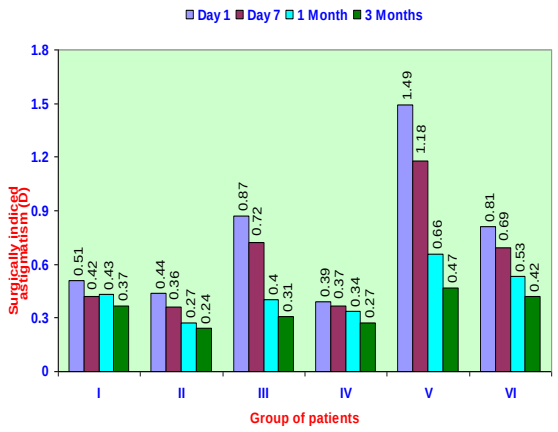
Distribution of surgically induced astigmatism:

Surgically induced astigmatism was calculated by using SIA Calculator based on Holladay et al method i.e. converting the pre-operative and post-operative astigmatism values in their components at X axis and at Y axis. Then Cartesian – coordinates is converted into astigmatic vector form.

The mean SIA in group I was 0.51 ± 0.59 D on 1st postoperative day, 0.42 ± 0.58 D on 7th post-operative day, 0.43 ± 0.35 D at 1 month follow up and 0.37± 0.39 D at 3 months follow-up (Graph 3).

The mean SIA in group II was 0.44 ± 0.79 D on 1st postoperative day, 0.36± 0.44 D on 7th post-operative day, 0.27 ± 0.77D at 1 month follow up and 0.24± 0.57 D at 3 months follow-up (Graph 3).

The mean SIA in group III was 0.87 ± 1.24 D on 1st postoperative day, 0.72 ± 1.67 D on 7th post-operative day, 0.40 ± 1.07 D at 1 month follow up and 0.31± 0.93 D at 3 months follow-up (Graph 3).



Graph 3: Bar graph showing distribution of surgically induced astigmatism in different groups at various follow-up periods

The mean SIA in group IV was 0.39 ± 0.83 D on 1st postoperative day, 0.37 ± 0.98 D on 7th post-operative day, 0.34 ± 0.60 D at 1 month follow up and 0.27± 0.43 D at 3 months follow-up (Graph 3).

The mean SIA in group V was 1.49 ± 1.10 D on 1st postoperative day, 1.18 ± 1.87 D on 7th post-operative day, 0.66 ± 1.01 D at 1 month follow up and 0.47± 0.70 D at 3 months follow-up (Graph 3).

The mean SIA in group VI was 0.81 ± 1.90 D on 1st postoperative day, 0.69 ± 1.81 D on 7th post-operative day, 0.53 ± 1.33 D at 1 month follow up and 0.42± 0.67 D at 3 months follow-up (Graph 3).

Uncorrected Visual Acuity (UCVA) in post-operative periods:

Distribution of Postoperative UCVA in Group I

Table 13: Distribution of Postoperative UCVA in Group I: (CCI 2.8)

UCVA	Day 1 (No.) %	Day 7 (No.) %	1 Month (No.) %	3 Months (No.) %
VA ≥ 6/9	13(65%)	14(70%)	16(80%)	16(80%)
6/9p to 6/12	5(25%)	4(20%)	3(15%)	3(15%)
6/12 p to 6/18	2(10%)	2(10%)	1(5%)	1(5%)
6/18p to 6/24	0	0	0	0
6/24p to 6/36	0	0	0	0
6/36p to 6/60	0	0	0	0
< 6/60	0	0	0	0

About 65 % of the patients in this group had an UCVA of > 6/9 on the 1st post-operative day. Of the remaining another 25 % of them had an UCVA of > 6/12. None of the patients had an UCVA of < 6/18. Lowest recorded UCVA was 6/18 on day 1 post-op.

On the 7th post-operative day, UCVA of > 6/9 was found in 70% of the patients.20% of the patients had UCVA > 6/12. None of the patients had an UCVA of < 6/18.Lowest recorded UCVA was 6/12p on day 7 post-op.

At 1 month post-operatively, however, as SIA value increased slightly, UCVA of >6/9 was found in 80% of the patients. 15% of the patients had UCVA >6/12. None of the patients had an UCVA of <6/18. Lowest recorded UCVA was 6/18 at 1 month post-op.

At 3 months post-operatively, in group I, as astigmatism was stabilized, UCVA of > 6/9 was seen in 80% of cases. 15% of the patients had UCVA > 6/12. None of the patients had an UCVA of < 6/18. Lowest recorded UCVA was 6/18 at 3 month post-op.

Distribution of postoperative UCVA in Group II

Table 14: Distribution of postoperative UCVA in Group II: (L 2.8)

UCVA	Day 1 (No.) %	Day 7 (No.) %	1 Month (No.) %	3 Months (No.) %
VA ≥ 6/9	10(50%)	8(40%)	13(65%)	15(75%)
6/9p to 6/12	6(30%)	5(25%)	5(25%)	4(20%)
6/12 p to 6/18	2(10%)	5(25%)	1(5%)	1(5%)
6/18p to 6/24	2(10%)	2(10%)	1(5%)	0
6/24p to 6/36	0	0	0	0
6/36p to 6/60	0	0	0	0
< 6/60	0	0	0	0

On 1st postoperative visit, an UCVA of > 6/9 was found in 50 % of the patients and an UCVA of > 6/12 was found in 30 % of the patients. Lowest recorded visual acuity was 6/24 in this group.

On 7th postoperative day, a slightly lower number of patients had an UCVA of >6/9 (i.e. 40 %).The number of patients with a UCVA of > 6/12 was 25%. Lowest recorded visual acuity was found to be 6/24.

At 1 month follow up, an UCVA of > 6/9 was found in 65 % of the patients and an UCVA of > 6/12 was found in 25 % of the patients. Lowest recorded visual acuity was found to be 6/24.

At 3 months follow up, an UCVA of > 6/9 was found in 75 % of the patients and an UCVA of > 6/12 was found in 20 % of the patients. Lowest recorded visual acuity was found to be 6/18p

Distribution of postoperative UCVA in Group III

Table 15: Distribution of postoperative UCVA in Group III (CCI 5.5)

UCVA	Day 1 (No.) %	Day 7 (No.) %	1 Month (No.) %	3 Months (No.) %
VA ≥ 6/9	10(50%)	11(55%)	13(65%)	13(65%)
6/9p to 6/12	7(35%)	6(30%)	5(25%)	5(25%)
6/12 p to 6/18	2(10%)	2(10%)	2(10%)	2(10%)
6/18p to 6/24	1(5%)	1(5%)	0	0
6/24p to 6/36	0	0	0	0
6/36p to 6/60	0	0	0	0
< 6/60	0	0	0	0

On the 1st postoperative day, an UCVA of >6/9 was found in 50% of the patients and an UCVA of >6/12 was also found in 35 % of the patients. Lowest recorded visual acuity was 6/24 in this group.

On 7th postoperative day, UCVA of >6/9 was found in 30% of the patients. Lowest recorded visual acuity was found to be 6/24.

At 1 month follow up, an UCVA of >6/9 was found in 65 % of the patients and an UCVA of >6/12 was found in 25% of the patients. Lowest recorded visual acuity was found to be 6/18.

At 3 months follow up, an UCVA of >6/9 was found in 65 % of the patients and an UCVA of >6/12 was found in 25% of the patients. Lowest recorded visual acuity was found to be 6/18.

Distribution of postoperative UCVA in Group IV

Table 16: Distribution of postoperative UCVA in Group IV: (L 5.5)

UCVA	Day 1 (No.) %	Day 7 (No.) %	1 Month (No.) %	3 Months (No.) %
VA ≥ 6/9	11(55%)	10(50%)	13(65%)	15(75%)
6/9p to 6/12	8(40%)	7(35%)	6(30%)	5(25%)
6/12 p to 6/18	2(10%)	3(15%)	1(5%)	0
6/18p to 6/24	1(5%)	0	0	0
6/24p to 6/36	0	0	0	0
6/36p to 6/60	0	0	0	0
< 6/60	0	0	0	0

In this group, on 1st postoperative visit, an UCVA of >6/9 was found in 55 % of the patients and an UCVA of > 6/12 was found in 40 % of the patients. Lowest recorded visual acuity was 6/24 in this group.

On 7th postoperative day, a slightly lower number of patients had an UCVA of >6/9 (i.e. 50%). The number of patients with a UCVA of > 6/12 was 35%. Lowest recorded visual acuity was found to be 6/18.

At 1 month follow up, an UCVA of > 6/9 was found in 65 % of the patients and an UCVA of > 6/12 was found in 30 % of the patients. Lowest recorded visual acuity was found to be 6/18.

At 3 months follow up, an UCVA of > 6/9 was found in 75 % of the patients and an UCVA of > 6/12 was found in 25 % of the patients. Lowest recorded visual acuity was found to be 6/12p.

Distribution of postoperative UCVA in Group V

Table 17: Distribution of postoperative UCVA in Group V: (CCI 5.5 SUTURED)

UCVA	Day 1 (No.) %	Day 7 (No.) %	1 Month (No.) %	3 Months (No.) %
VA ≥ 6/9	7(35%)	9(45%)	11(45%)	13(65%)
6/9p to 6/12	7(35%)	5(25%)	5(25%)	6(30%)
6/12 p to 6/18	6(30%)	4(20%)	4(20%)	1(5%)
6/18p to 6/24	0	2(10%)	0	0
6/24p to 6/36	0	0	0	0
6/36p to 6/60	0	0	0	0
< 6/60	0	0	0	0

In this group, on 1st postoperative visit, an UCVA of > 6/9 was found in 35 % of the patients and an UCVA of > 6/12 was found in 35 % of the patients. Lowest recorded visual acuity was 6/18 in this group.

On 7th postoperative day, UCVA of > 6/9 was seen in 45% patients. The number of patients with a UCVA of > 6/12 was 25%. Lowest recorded visual acuity was found to be 6/24.

At 1 month follow up, an UCVA of > 6/9 was found in 55 % of the patients and an UCVA of > 6/12 was found in 25 % of the patients. Lowest recorded visual acuity was found to be 6/18.

At 3 months follow up, an UCVA of > 6/9 was found in 65 % of the patients and an UCVA of > 6/12 was found in 30 % of the patients. Lowest recorded visual acuity was found to be 6/18 p.

Distribution of postoperative UCVA in Group VI

Table 18: Distribution of postoperative UCVA in Group VI: (L5.5 SUTURED)

UCVA	Day 1 (No.) %	Day 7 (No.) %	1 Month (No.) %	3 Months (No.) %
VA ≥ 6/9	8(40%)	7(35%)	12(60%)	15(75%)
6/9p to 6/12	7(35%)	9(45%)	7(35%)	4(20%)
6/12 p to 6/18	5(25%)	4(20%)	1(5%)	1(5%)
6/18p to 6/24	0	0	0	0
6/24p to 6/36	0	0	0	0
6/36p to 6/60	0	0	0	0
< 6/60	0	0	0	0

In this group, on 1st postoperative visit, an UCVA of > 6/9 was found in 40 % of the patients and an UCVA of > 6/12 was found in 35 % of the patients. Lowest recorded visual acuity was 6/18 in this group.

On 7th postoperative day, UCVA of >6/9 was seen in 35% patients. The number of patients with a UCVA of >6/12 was 45%. Lowest recorded visual acuity was found to be 6/18.

At 1 month follow up, an UCVA of > 6/9 was found in 60 % of the patients and an UCVA of > 6/12 was found in 35 % of the patients. Lowest recorded visual acuity was found to be 6/18.

At 3 months follow up, an UCVA of > 6/9 was found in 75 % of the patients and an UCVA of > 6/12 was found in 20 % of the patients. Lowest recorded visual acuity was found to be 6/18.

Statistical analysis of surgically induced astigmatism:

Comparisons between groups: They were performed using a 'paired t-test for comparison of means'.

Table 19: Results of paired t-test for comparison of SIA magnitude between various groups on post-op day 1:

Gps. compared	Mean Difference	Significance level	Significance at 95% C.I.
Gp. I vs II	0.2094	0.198	Not Significant
GpIII vs IV	0.6902	0.041	Significant
GpV vs VI	0.6228	0.115	Not Significant
GpIII vs V	2.0356	0.0019	Highly Significant
GpIV vs VI	1.5112	0.0012	Highly Significant

Table 20: Results of pair-t test for comparison of SIA magnitude between various groups on post -op day 7:

Gps. compared	Mean Difference	Significance level	Significance at 95% C.I.
Gp. I vs II	0.2976	0.170	Not Significant
GpIII vs IV	0.4074	0.217	Not Significant
GpV vs VI	0.5541	0.192	Not Significant
GpIII vs V	1.4258	0.019	Significant
GpIV vs VI	0.4643	0.014	Significant

Table 21: Results of paired t-test for comparison of SIA magnitude between various groups on 1 month follow up:

Gps. compared	Mean Difference	Significance level	Significance at 95% C.I.
Gp. I vs II	0.2560	0.119	Not Significant
GpIII vs IV	0.2864	0.195	Not Significant
GpV vs VI	0.0740	0.423	Not Significant`
GpIII vs V	0.3784	0.019	Significant
GpIV vs VI	0.5909	0.043	Significant

Table 22: Results of paired t-test for comparison of SIA magnitude between various groups on 3 month follow up:

Gps. compared	Mean Difference	Significance level	Significance at 95% C.I.
Gp. I vs II	0.3615	0.189	Not Significant
GpIII vs IV	0.2824	0.109	Not Significant
GpV vs VI	0.0623	0.399	Not Significant
GpIII vs V	0.3890	0.031	Significant
GpIV vs VI	0.6091	0.051	Significant

DISCUSSION

In ophthalmology, perhaps no other surgery has undergone such rapid and drastic revolutionary change in the past four decade, as has cataract surgery. The transition from ICCE to ECCE to phacoemulsification has really been a major breakthrough in cataract extraction.

Despite its great potential, cataract surgery has often in the past failed because of a large number of factors. One of the most important of which has been the surgically induced astigmatism. Hence a reduction in surgically induced astigmatism is one of the primary goals of modern day surgical technique.

Results obtained from the study are discussed in the light of available literature as follows:

Donders [4] (1862) emphasized induced corneal flattening with cataract surgery. Jaffe et al [5] said that anteriorly placed incisions would induce more astigmatism.

Zheng et al [6] (1997) and Koryntal et al [7] (1998) found lesser induced corneal flattening with scleral incisions than the limbal incisions.

Masket et al [8] (1991) found that undesired SIA is likely in sutureless cataract surgeries if incision is >4 mm and is placed on non-steepest meridian. Samuelson et al [9] (1991) proposed that maximal incision length that would minimize corneal flattening >0.25 D was 3mm. Motsumoto et al [10] (2001) proposed, that in order to prevent astigmatism postoperatively, the incision should be placed at the steepest meridian in eyes with preoperative astigmatism greater than 0.5D, and for preoperative astigmatism greater than 1.2D, a 3.2mm incision at the corneal limbus is insufficient and a wider incision or an additional incision is required to achieve resultant astigmatically free cornea.

Singer et al [11] (1991) reported a study on as series of 62 eyes with 6 mm and 7 mm, superior scleral tunnel frown incision and implantation of a 6 mm or 7 mm one piece biconvex PMMA PCIOL lens. They found that mean induced keratometric cylinder was 0.80D 1st day, 0.74 D at one month using vector analysis.

Sinskey et al [12] (1994) reported post-operative induced astigmatism in 55 consecutive patients undergoing cataract extraction using a 6 mm no-stitch frown incision and implantation of a 6mm optic 3 piece PCIOL using vector analysis. They found mean induced keratometric cylinder (ATR) of 0.70 D on one day, 0.7D at one week, 0.50D at one month and 0.50 at 3 months.

He et al [13] (2000) in their clinical investigation on cataract surgery with 2.8 mm incision showed that the mean diopters of astigmatism at post – operative period was day (1.09 0.51), 1 week (1.02 047D), 1 month (0.88 0.52) and 3 moths (0.81 0.62 D).

Giansanti et al [14] (2006) studied Surgically induced astigmatism induced by 2.75mm clear corneal incision placed at different location and found that 2.75mm clear corneal incision produces a small change of corneal cylinder regardless of incision site.

Singer et al [11] showed that the technique of horizontal suture closure produces a rapid stabilization of the wound and prevents a wound slippage. A cross stitch (figure of eight or infinity suture) on the other had too available schools of opinion. Some authors believe that it has a radial and a horizontal component both and should provide a stable wound held together without producing much induced astigmatism.

Michael et al [15] (2005) reported that a cross stitch causes a distortion of the wound and may therefore fail to stabilize the cataract incision and therefore, may still fail to control the ATR drift. Rainer et al [16] (1998) studied SIA after 5.0mm sclero-corneal (limbal) valve incision and reported initiat mean WTR shift of 0.35D followed by ATR shift to mean of -0.30D after 1 month.

Shepherd et al [17] (1989) reported that a 4.0 to 6.0 mm incision at 12 o'clock closed with one or more sutures induces an immediate WTR astigmatism followed by ATR decay also circumferential suturing can induce less WTR astigmatism than radial suturing.

Pfleger et al [18] reported that 4.0 to 5.0 mm self sealing sutureless incisions results in early stability, with final induced astigmatism that is ATR.

Niels et al [19] concluded that early stability was only seen in the sutureless group.

Conclusions made by pioneers in the field of postoperative astigmatism were:

SIA after cataract surgery is mainly corneal.

Incisions play major role in induced astigmatism.

In our study SIA was studied for evolution, stability and its magnitude in 6 study group: Surgically induced astigmatism was calculated using SIA Calculator based on the method of Holladay et al [20] i.e. converting the pre-operative and post-operative astigmatism values in their components at X axis and at Y axis. Then Cartesian – coordinates is converted into astigmatic vector form.

The mean SIA in group I (CCI 2.8) was 0.51 ± 0.59 D on 1st postoperative day, 0.42 ± 0.58 D on 7th post-operative day, 0.43 ± 0.35 D at 1 month follow up and 0.37± 0.39 D at 3 months follow-up. This declined in 3 months from 0.51 ± 0.59 D to 0.37± 0.39 D (ATR) and stabilized in 80 % of cases.

About 65 % of the patients in this group had an UCVA of > 6/9 on the 1st post-operative day. Of the remaining another 25 % of them had an UCVA of > 6/12. None of the patients had an UCVA of < 6/18. Lowest recorded UCVA was 6/18 on day 1 post-op.

On 7th post-operative day, UCVA of > 6/9 was found in 70% of the patients.20% of the patients had UCVA > 6/12. None of the patients had an UCVA of < 6/18.Lowest recorded UCVA was 6/12p on day 7 post-op.

At 1 month post-operatively, however, as SIA value increased slightly, UCVA of > 6/9 was found in 80% of the patients. 15% of the patients had UCVA > 6/12. None of the patients had an UCVA of < 6/18. Lowest recorded UCVA was 6/18 at 1 month post-op.

At 3 months post-operatively, UCVA of > 6/9 was seen in 80% of cases showing that the astigmatism had stabilized.15% of the patients had UCVA > 6/12. None of the patients had an UCVA of < 6/18. Lowest recorded UCVA was 6/18 at 3 month post-op.

The mean SIA in group II (L 2.8) was 0.44 ± 0.79 D on 1st postoperative day, 0.36± 0.44 D on 7th post-operative day, 0.27 ± 0.77D at 1 month follow up and 0.24± 0.57 D at 3 months follow-up. This declined in 3 months from 0.44 ± 0.79 D to 0.24± 0.57 D (ATR) and stabilized in 90 % of cases.

On 1st postoperative visit, an UCVA of > 6/9 was found in 50 % of the patients and an UCVA of > 6/12 was found in 30 % of the patients. Lowest recorded visual acuity was 6/24 in this group.

On 7th postoperative day, a slightly lower number of patients (40%) had an

UCVA of >6/9. The number of patients with a UCVA of > 6/12 was 25%. Lowest recorded visual acuity was found to be 6/24.

At 1 month follow up, an UCVA of > 6/9 was found in 65 % of the patients and an UCVA of > 6/12 was found in 25 % of the patients. Lowest recorded visual acuity was found to be 6/24.

At 3 months follow up, an UCVA of > 6/9 was found in 75 % of the patients and an UCVA of > 6/12 was found in 20 % of the patients. Lowest recorded visual acuity was found to be 6/18p

The mean SIA in group III (CCI 5.5) was 0.87 ± 1.24 D on 1st postoperative day, 0.72 ± 1.67 D on 7th post-operative day, 0.40 ± 1.07 D at 1 month follow up and 0.31± 0.93 D at 3 months follow-up. This declined in 3 months from 0.87 ± 0.1.24 D to 0.31± 0.93 D (ATR) and stabilized in 85 % of cases.

On the 1st postoperative day, an UCVA of >6/9 was found in 50 % of the patients and an UCVA of > 6/12 was also found in 35 % of the patients. Lowest recorded visual acuity was 6/24 in this group.

On 7th postoperative day, UCVA of >6/9 was found in 30% of the patients. Lowest recorded visual acuity was found to be 6/24.

At 1 month follow up, an UCVA of >6/9 was found in 65 % of the patients and an UCVA of > 6/12 was found in 25 % of the patients. Lowest recorded visual acuity was found to be 6/18.

At 3 months follow up, an UCVA of > 6/9 was found in 65 % of the patients showing that the astigmatism had stabilized. UCVA of > 6/12 was found in 25 % of the patients. Lowest recorded visual acuity was found to be 6/18.

The mean SIA in group IV (L 5.5) was 0.39 ± 0.83 D on 1st postoperative day, 0.37 ± 0.98 D on 7th post-operative day, 0.34 ± 0.60 D at 1 month follow up and 0.27± 0.43 D at 3 months follow-up. This declined in 3 months from 0.39 ± 0.83 D to 0.27± 0.43 D (ATR) and stabilized in 90 % of cases.

In this group, on 1st postoperative visit, an UCVA of > 6/9 was found in 55 % of the patients and an UCVA of > 6/12 was found in 40 % of the patients. Lowest recorded visual acuity was 6/24 in this group.

On 7th postoperative day, a slightly lower number of patients (50%) had an UCVA of > 6/9 .The number of patients with a UCVA of > 6/12 was 35%. Lowest recorded visual acuity was found to be 6/18.

At 1 month follow up, an UCVA of > 6/9 was found in 65 % of the patients and an UCVA of > 6/12 was found in 30 % of the patients. Lowest recorded visual acuity was found to be 6/18.

At 3 months follow up, an UCVA of > 6/9 was found in 75 % of the patients showing that the astigmatism had stabilized. UCVA of > 6/12 was found in 25 % of the patients. Lowest recorded visual acuity was found to be 6/12p.

The mean SIA in group V (CCI 5.5 SUTURED) was 1.49 ± 1.10 D on 1st postoperative day, 1.18 ± 1.87 D on 7th post-operative day, 0.66 ± 1.01 D at 1 month follow up and 0.47± 0.70 D at 3 months follow-up. This declined in 3 months from 1.49 ± 1.10 D to 0.47± 0.70 D (ATR) and stabilized in 60% of cases. The remaining 40% cases had WTR astigmatism.

In this group, an UCVA of > 6/9 was found in 35 % of the patients on 1st postoperative day and an UCVA of > 6/12 was found in 35 % of the patients. Lowest recorded visual acuity was 6/18 in this group.

On 7th postoperative day, UCVA of > 6/9 was seen in 45% patients. The number of patients with a UCVA of > 6/12 was 25%. Lowest recorded visual acuity was found to be 6/24.

At 1 month follow up, an UCVA of > 6/9 was found in 55 % of the patients and an UCVA of > 6/12 was found in 25 % of the patients. Lowest recorded visual acuity was found to be 6/18. At 3 months follow up, an UCVA of > 6/9 was found in 65 % of the patients showing that the astigmatism

had stabilized. UCVA of > 6/12 was found in 30 % of the patients. Lowest recorded visual acuity was found to be 6/18p

The mean SIA in group VI (L 5.5 SUTURED) was 0.81 ± 1.90 D on 1st postoperative day, 0.69 ± 1.81 D on 7th post-operative day, 0.53 ± 1.33 D at 1 month follow up and 0.42± 0.67 D at 3 months follow-up. This declined in 3 months from 0.81 ± 1.90 D to 0.42± 0.67 D (ATR) and stabilized in 75 % of cases. The remaining 25% cases had WTR astigmatism.

On 1st postoperative visit, an UCVA of > 6/9 was found in 40 % of the patients and an UCVA of > 6/12 was found in 35 % of the patients. Lowest recorded visual acuity was 6/18 in this group.

On 7th postoperative day, UCVA of >6/9 was seen in 35% patients. The number of patients with a UCVA of > 6/12 was 45%. Lowest recorded visual acuity was found to be 6/18.

At 1 month follow up, an UCVA of > 6/9 was found in 60 % of the patients and an UCVA of > 6/12 was found in 35 % of the patients. Lowest recorded visual acuity was found to be 6/18.

At 3 months follow up, an UCVA of > 6/9 was found in 75 % of the patients showing that the astigmatism had stabilized. UCVA of > 6/12 was found in 20 % of the patients. Lowest recorded visual acuity was found to be 6/18.

Thus, in both group V (CCI 5.5 SUTURED) and group VI (L 5.5 SUTURED) where 5.5mm incisions were closed with single figure of eight 10-0 nylon suture, initial WTR astigmatism was 70% and 55% respectively. It further increased on 7th post-op day to 75% and 60% respectively. However, it declined at 1 month and shifted towards ATR in 3 month post-operatively which was statistically significant.

Comparison within 6 groups:

On day 1 post-op, we found no statistically significant difference between mean SIA in group I (CCI 2.8) and group II (L 2.8) (P= 0.198)

There was also statistically significant difference between mean SIA in group III (CCI 5.5) and group IV (L 5.5) (P= 0.041)

There was no statistically significant difference between mean SIA in group V (CCI 5.5 SUTURED) and group VI (L 5.5 SUTURED) (P= 0.115)

We found statistically very highly significant difference between mean SIA in group III (CCI 5.5) and group V (CCI 5.5 SUTURED) (P= 0.001)

We also found statistically very highly significant difference between mean SIA in group IV (L 5.5) and group VI (L 5.5 SUTURED) (P= 0.001)

On day 7 post-op, we found no statistically significant difference between mean SIA in group I (CCI 2.8) and group II (L 2.8) (P= 0.170)

There was also no statistically significant difference between mean SIA in group III (CCI 5.5) and group IV (L 5.5) (P= 0.217)

There was also no statistically significant difference between mean SIA in group V (CCI 5.5 SUTURED) and group VI (L 5.5 SUTURED) (P= 0.192)

We found statistically highly significant difference between mean SIA in group III (CCI 5.5) and group V (CCI 5.5 SUTURED) (P= 0.019)

We also found statistically highly significant difference between mean SIA in group IV (L 5.5) and group VI (L 5.5 SUTURED) (P= 0.014)

At 1 month post-op, we found no statistically significant difference between mean SIA in group I (CCI 2.8) and group II (L 2.8) (P= 0.119)

There was also no statistically significant difference between mean SIA in group III (CCI 5.5) and group IV (L 5.5) (P= 0.195)

There was also no statistically significant difference between mean SIA in

Group V (CCI 5.5 SUTURED) and group VI (L 5.5 SUTURED) (P= 0.423)

We found statistically highly significant difference between mean SIA in group III (CCI 5.5) and group V (CCI 5.5 SUTURED) (P= 0.019)

We also found statistically highly significant difference between mean SIA in group IV (L 5.5) and group VI (L 5.5 SUTURED) (P= 0.043)

At 3 month post-op, we found no statistically significant difference between mean SIA in group I (CCI 2.8) and group II (L 2.8) (P= 0.0189)

There was also no statistically significant difference between mean SIA in group III (CCI 5.5) and group IV (L 5.5) (P 0.109)

There was also no statistically significant difference between mean SIA in group V (CCI 5.5 SUTURED) and group VI (L 5.5 SUTURED) (P= 0.399)

We found statistically highly significant difference between mean SIA in group III (CCI 5.5) and group V (CCI 5.5 SUTURED) (P= 0.031)

We also found statistically highly significant difference between mean SIA in group IV (L 5.5) and group VI (L 5.5 SUTURED) (P= 0.051)

CONCLUSION

Thus, from these findings and statistical evaluation, we conclude that

1. Magnitude of surgically induced astigmatism was low in all the groups and mean value of SIA magnitude was less than 0.99 D in majority of groups except in group V (CCI 5.5 SUTURED) where maximum SIA was found 1.49 D on first post-op day. The single infinity suture at 5.5mm clear corneal wound in this group was responsible for higher astigmatism.
2. Magnitude of surgically induced astigmatism was found to be least in group II (L 2.8). Maximum flattening of 0.24 ± 0.57 D (ATR) at 3 month post-op follow-up was observed.
3. Maximum SIA was noted in group V (CCI 5.5 SUTURED) where a 5.5mm incision at clear cornea was sutured with one infinity 10-0 nylon suture. Its magnitude on 1st postoperative day was 1.49 ± 1.10 D which declined in 3 months from 1.49 ± 1.10 D to 0.47± 0.70 D (ATR) to 0.47± 0.70 D and was stabilized in 60 % of cases.
4. In group I (CCI 2.8), II (L 2.8), III (CCI 5.5) and IV (L 5.5), majority of patients had initial ATR astigmatism. Percentage of ATR further increased in 3 month post-op follow-up in all four groups.
5. In group V (CCI 5.5 SUTURED) and VI (L 5.5 SUTURED) where 5.5 mm incision were sutured with one infinity 10-0 nylon suture, initial WTR astigmatism was found (70% and 55% respectively) which further increased on 7th post-op day to 75% and 60% (WTR) respectively. However, it declined in the next follow-up at 1 month period (60% and 45% WTR). At the end it shifted towards ATR in 3 month follow-up (60% and 75% ATR).
6. On comparison between group III (CCI 5.5) and V (CCI 5.5 SUTURED) and between group IV (L 5.5) and VI (L 5.5 SUTURED), surgically induced astigmatism was more in sutured wounds which was statistically significant at 3 month follow-up (p=0.031 and p=0.051 respectively).
7. On comparison between sutureless group I, II and group III, IV where equal size incisions were placed one at clear cornea and other at limbus, surgically induced astigmatism was slightly more in incision, placed at clear cornea than incision placed at limbus which was statistically insignificant at 3 month follow-up.
8. Visual recovery was fast in case of groups I and II followed groups III and IV, followed by groups V and VI.
9. There is not much difference in the magnitude of SIA in phacoemulsification via 5.5 mm self sealing sutureless incision with rigid IOL implantation as compared to 2.8 mm self sealing sutureless incision with foldable IOL implantation after 3 months postoperative follow-up

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