Central Medical College Journal
Vol 7 No 2 July 2023
DOI: https://doi.org/10.3329/cemecj.v7i2.74416

Original Article

Management of Corneal Astigmatism by Limbal Relaxing Incisions during Phacoemulsification

Islam MA[1], Alam A[2], Hossain MS[3], Alam MN[4], Rasel SMSB[5], Chowdhury MHJ[6].

Abstract

Background: *Phacoemulsification is one of the most successfully and commonly performed cataract surgeries worldwide. Modern cataract and refractive surgery aims not only to improve vision but to provide a good unaided visual acuity. Correcting astigmatic errors and control of surgically induced astigmatism are now an integral part of such operative procedures.* ***Objective:*** *To analyze the effectiveness and safety of limbal relaxing incisions (LRI) in correcting keratometric astigmatism during phacoemulsification.* ***Method:*** *A prospective study of two groups: control group and treatment group. Treatment group included 50 eyes of 50 patients who had combined clear corneal phacoemulsification, IOL implantation and LRI. Control group included 50 eyes of 50 patients who had clear corneal phacoemulsification and IOL implantation. Postoperative keratometric astigmatism was measured at 1 week, 1 month, 3 months and 6 months.* ***Result:*** *LRI significantly decreased keratometric astigmatism in patients with preexisting astigmatism compared with astigmatic changes in the control group. In eyes with LRI, the mean keratometric astigmatism was 0.31±0.17 D (range 0 to 0.5 D) at 1 week, 0.39± 0.21 D (range 0 to 0.85 D) at 1 month, respectively reduced by 2.43 D and 2.29 D at 1 week and 1 month postoperatively (P=0.000, P=0.000), and postoperative astigmatism was stable until 6 months follow-up. The keratometric astigmatism of all patients decreased to less than 1.00 D postoperatively.* ***Conclusion:*** *LRI was a practical, simple, safe and effective method to reduce preexisting astigmatism during phacoemulsification.*

Key words: *Astigmatism, Limbal relaxing incision, Cataract, Phacoemulsification.*

Introduction: Astigmatism induces distortion of the image leading to compromise quality of vision. In order to achieve better visual results, theeffect of postoperative astigmatism should beminimized through several techniquesincluding intraoperative relaxing incisions, toric intraocular lens (IOL) implantation or postoperative vision correctionby ablative refractive surgery by excimerlaser; each with its own advantages anddisadvantages. Technological innovations and surgical developments in recent times have provided new methods for correction of astigmatism. Herein, we report the safety and efficacy oflimbal relaxing incisions (LRIs) for correctionof pre-existing corneal astigmatism during phacoemulsification. The first suggestion of refractive correction was by Hermann Boerhaave in 1708, when he suggested that high myopia could be corrected by couching the clear crystalline lens.[1] The first suggestions of corneal surgery to alter the refractive power of the eye were by Dutch ophthalmologist Snellen, in 1869. Snellen documented the possible correction of corneal astigmatism,[2] based on prior observations by Donders, of whom Snellen was a student, that corneal scars following cataract surgery increased astigmatism.[3] Since 1998, the temporal clear corneal incision (CCI)

1. ***Dr. Mohammad Ariful Islam,*** *Assistant Professor (Ophthalmology), Chandpur Medical College, Chandpur.*
2. ***Dr. Afroza -E- Alam,*** *Junior Consultant (Surgery), Upazila Health Complex, Laksam, Cumilla.*
3. ***Dr. Mohammad Sabbir Hossain,*** *Assistant Professor (Orthopaedic Surgery) Chandpur Medical College, Chandpur.*
4. ***Dr. Mohammad Nurul Alam,*** *Assistant Professor (Biochemistry), Chandpur Medical College, Chandpur.*
5. ***Dr. S M Shafiul Bari Rasel,*** *Medical Officer (Ophthalmology), Sheikh FazilatunnessaMujib Eye Hospital, & Training Institute, Gopalganj.*
6. ***Dr. Md. Hasnat Jaki Chowdhury,*** *Emergency Medical Officer, 250 bed General Hospital, Chandpur.*

Correspondence : ***Dr. Mohammad Ariful Islam,*** *Assistant Professor (Ophthalmology), Chandpur Medical College, Chandpur. Email: drarifuleye@gmail.com ,Mob: +8801717855790*

Received date: 20 August 2023
Accepted reviewed version date: 14 April 2024

Central Medical College Journal
Vol 7 No 2 July 2023
DOI: https://doi.org/10.3329/cemecj.v7i2.74416

has been the most commonly used incision in cataract surgery.[4] Currently, cataract surgery is performed through the smallest incision of any surgery on a major organ system in the human body. In most procedures, the incision is merely a portal; however, it is well recognizedthat the design and construction of the corneal incision for cataract surgery is fundamental to the functional result of the surgery. Efforts to reduce the incision size to 2.2 mm and smaller have required several innovations in intraocular lens (IOL) design, instrumentation, and phacoemulsification technology. Each step taken in reducing the incision size comes with mixed success but has led ultimately to measurable improvements in outcomes. The advent of phacoemulsification, foldable intraocular lenses (IOLs), and improved incision designs has decreased the incidence and extent of surgically induced astigmatism in cataract patients. Aproximately 15-20% of cataract patients, however, have more than 1.5 diopters (D) of keratometric astigmatism, refractive astigmatism, or both.[5] Interest in reducing preexisting astigmatism simultaneously with cataract surgery has grown in recent years. Available options include a clear corneal cataract incision along the steep meridian,[6] astigmatic keratotomy (AK),[7] toric IOL implantation,[8] opposite clear corneal incision,[9] and limbal relaxing incisions (LRIs) or corneal relaxing incisions (CRIs).[10] According to Budak and Friedman,[11] CRI or LRI is effective in eyes with astigmatism. In this study, we analyzed the effectiveness of LRI in 50 eyes of 50 patients.

Method:

During July 2019 to December 2019 cataract patients with more than 1.0 D astigmatism admitted in Sheikh FazilatunnessaMujib Eye Hospital & Training Institute (SFMEHTI), Goplganj, were included in this study. Based on the patients' willingness, all patients were divided into two groups: control group and treatment group. The treatment group included patients who had combined clear corneal phacoemulsification, IOL implantation and LRI. The control group included patients who had traditional clear corneal phacoemulsification and IOL implantation. Patients with irregular corneal astigmatism or astigmatism due to corneal injury,pterygium were excluded. A complete general ophthalmic examination was done in all patients with uncorrected visual acuity (UCVA), best spectacle-corrected visual acuity (BSCVA), keratometry and autorefractometerreadings, slitlamp and retinal evaluation, tonometry and pachymetrybefore surgery. A drawing noting was identifiedwith a marker dyed on the meridian of astigmatismto minimize the effect of eye rotation onsurgical accuracy. Pachymetric readings were takenat the position of 3.5 mm away from the cornealcenter. Then LRI was made with a1 50 knife, to a depth of 90% corneal thickness andcentered along the meridian of the astigmatism. The LRI length was decided according to the nomogrambased on preoperative keratometric astigmatismmeasured by keratometry, and age of patients (Table1).

Table 1 The nomogram of CRI:

Age Effect	
(Dioptor of astigmatismcorrected/mm)	
20~29	0.40
30~ 39	0.45
40~49	0.55
50~59	0.60
60~ 69	0.65
70~79	0.75

Note: 1. Depth ≥90% corneal thickness; 2. Length not shorter than1.5 mm; 3. Length not longer than 6 mm; 4. Additional incision canbe done at the opposite side on the same meridian.

Superior LRI was made for with-the-rule (WTR) astigmatism and nasal LRI for against-the rule (ATR) astigmatism (Fig.1)**.**

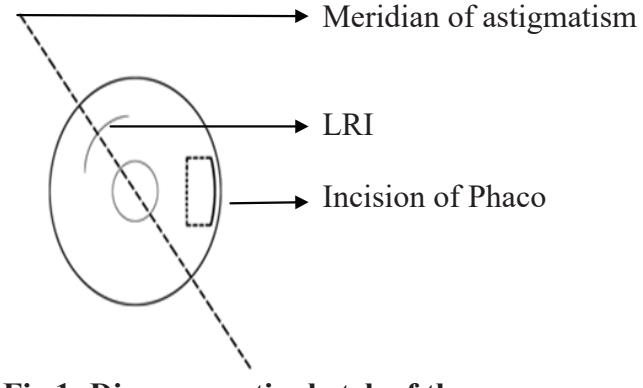

Fig 1: Diagrammatic sketch of the surgery.

Received date: 20 August 2023
Accepted reviewed version date: 14 April 2024

DOI: https://doi.org/10.3329/cemecj.v7i2.74416

Phacoemulsification and in-bag foldable IOL implantation were performed through the 2.4 to 2.8 mm temporal clear corneal incision. The clear corneal incision was placed along 180-degree meridian in right eyes and 30-degree meridian in left eyes. Cataract surgery was done at the conclusion of LRI procedure. All procedures were performed by single surgeon. The power of the intraocular lens was calculated with SK/T formula. All the patients were prescribed 0.3% moxifloxacin 4 times a day for four weeks postoperatively.Prednisolone acetate (1%) was also given 8 times a day for 1 week, 6 times a day for 1week, 5 times a day for 1 week, 4 times a day for 1week, 3 times a day for 1 week, 2 times a day for 1 week and 1 time a day for 1 week. Xibrofen 0.3% 2 times a day for 4 weeks. Postoperative keratometri castigmatism was measured at 1 week, 1month, 3 months and 6 months. Independent T test andpaired T test were used to analysis the differencebetween the two groups and the astigmatism changesof the treatment group postoperatively.

Result:

The treatment group included 50 eyes of 50 patients. The mean age of the 27 men and 23 women was 57.75±2.37 years (range 45 to 65 years). The mean preoperative keratometric astigmatismwas 2.77±0.47 (range 1.0 to 3.5 D). The controlgroup included 50 eyes of 50 patients. The meanage of the 26 men and 24 women was 60.77±2.40years (range 46 to 65 years). The mean preoperativekeratometric astigmatism was2.79±0.67D (range1.0 to 3.0 D).

Treatment group

In eyes with LRI, the mean keratometricastigmatism was 0.29±0.17 D (range 0 to 0.5 D) 1week, 0.41±0.21 D (range 0 to 0.82 D) 1 month,0.42±0.14 D (range 0.12 to 0.75) 3 months and0.49±0.13 D (0.25 to 0.75 D) 6 months respectivelyreduced by 2.42 D, 2.30 D, 2.29 D and 2.20 Dpostoperatively with statistical significance of P=0.000, P=0.000, P=0.000 and P=0.000. Thekeratometric astigmatism of all patients decreasedto less than 1.00 D postoperatively. According tothe power of the preexisting corneal astigmatismand age of patients, the mean length of the incisionwas 3.27±0.79 mm (range 2 to 5 mm).

Control group

The 50 eyes of control group keratometric astigmatism postoperatively had no signi ficantchanges compared to preexisting keratometri castigmatism 2.79±0.67D. The average keratometri castigmatism postoperatively was 2.72±0.57D at1 week, 2.76±0.45 D at 1 month, 2.67±0.58 D at 3months and 2.65±0.58 D at 6 months.

Difference between control group and treatmentgroup There were significant difference between thepostoperative keratometric astigmatism of thecontrol group and treatment group (Table 2).

Table 2: Difference in mean of keratometric astigmatism over time between control group and treatment group:

Control	Treatment	P	
Preoperative	2.79±0.67	2.77±0. 47	0.311
1 week	2.72±0.57	0.29±0.17	0.000
1 month 0.000	2.76±0.45	0.41±0.21	
3 months 0.000	2.67±0.58	0.42±0.14	
6 months 0.000	2.65±0.58	0.49±0.13	

Changes of keratometric astigmatism axis andcomplications

The change of keratometric astigmatism axisis given in Table 3.The axial changes above showed that thetreatment group had higher rate of more than 10°changes of astigmatism. Vector analysis of thischange showed that there was no eye werecorrectedmore than 1.00 D.

Table 3 Axis changes of two groups:

Control group	Treatment Group	
	(n/%)	(n/%)
Less than 5°	21/84	16/64
5° to 10°	4/16	3/12
10° to 45°		2/8
45° to 90°		4/16

All the cases had no ocular perforationsduring surgery, and no wound grapes.Postoperative complications such as itching or mildpain for 1 or 2 weeks occurred in some patients.

Received date: 20 August 2023
Accepted reviewed version date: 14 April 2024

Discussion:

The refractive power difference between thecrossing meridians of the corneal anterior surfacecontributes very importantly to the total ocularastigmatism, although the lens is another source ofastigmatism. The treatment of the preexistingastigmatism and surgically reduced astigmatismaffect the quality of cataract surgery as one ofrefractive surgery. There are several approaches for reducingpreexisting astigmatism during cataract surgery.Astigmatic keratotomy (AK) has been used tocorrect preexisting keratometric astigmatism duringcataract surgery.[7] The AKincisions are placed less than 3.0 mm away from thecenter of the cornea, which increases the risk ofinducing irregular astigmatism and postoperationglare. Torsional diplopia may be induced by meridionalaniseikonia, which alters the spatial sense.[12] The results of AK may vary, andfluctuation in refraction may occur.[13] Another incisional approach is the use of opposite clear corneal incisions.[14] In this technique, 2 standard cataract incisions were made 180 degrees apart along the steep meridian. Lever et al[9] reported that the mean astigmatism correction was 2.06 D for incisions ranging from 2.8 to 3.5 mm. However, the standard deviation for the mean astigmatism correction was not reported. Because the second incision enters the anterior chamber, this approach is more invasive than CRI.Leyland et al.[8] T has recently use toric IOL implantation for correcting preexisting astigmatism. This approach has the advantage of excellent optical quality, but postoperative rotation of the toric IOL is a main concern. They reported that 18% of IOLs rotated more than 30 degrees. Sun et al.[14] reported that 7% of IOLs rotated more than 40 degrees. Modifications of toric IOL designs are needed to address this problem. An additional drawback to the use of toric IOLs is that only 2.00 D and 3.50 D of cylindrical power are currently available, which correct 1.40 D and 2.30 D of astigmatism at the corneal plane respectively. The most basic requirement is the placement of incision along the steep corneal meridian, to take advantage of the wound induced flattening.[6] In light of the disadvantages described; LRI seems to be an excellent alternative for reducing preexisting keratometric astigmatism during cataract surgery. Our results demonstrated that LRI significantly decreased keratometric astigmatism in patients with preexisting astigmatism compared with astigmatic changes in the control group. The keratometric astigmatism of all patients decreased to less than 1.00 D postoperatively. The main length and depth of incision have been the main factors manipulated in controlling the degree of astigmatic correction. There was no ocular perforation in our series, suggesting a good safety profile for using an RK diamond knife set at 95% depth of corneal thickness. The depth incision was 90% of corneal thickness and the incision length was decided according to a nomogram based on age and preoperative corneal astigmatism measured by keratometry.Although no significant complications occurred in our patients, one must be aware of the potential complications such as placement of the incisions on the wrong or opposite meridian, infection, and loss of BSCVA. There is a risk of denervation of the cornea with long incisions. Main incision for cataract surgery and LRI that are too close to each other at the ends must be avoided. Further studies are needed to ascertain how long incisions cause this complication.In our series, LRI was placed before the cataract surgery. An obvious advantage of performing incision before cataract surgery is that there might be greater variability in corneal thickness from intraoperative corneal swelling. In addition, there might be more variability in the intraocular pressure, which could affect the depth of the incisions.

Limitations:

1. Small sample size.
2. Assessment of 90% depth of cornea at the limbus with a 150 knife were needed very careful attention.
3. Subsequent follow-up after postoperative refraction were challenging.
4 . Not all age group of patients were included.

Author's Contributions:

All the authors were contributed in various parts of the publication from concept and design, acquisition of data, analysis & interpretation of data and drafting of the manuscript.

Declaration of Conflicts:

The authors declare that, there is no conflict of interest regarding the publication of this article.

Received date: 20 August 2023
Accepted reviewed version date: 14 April 2024

Conclusion:
LRI is a practical, simple, safe and effective method to reduce preexisting astigmatism during cataract surgery.Advantages of LRI include technical ease, minimal instrument requirements, preservation of the optical qualities of the cornea, no complaint of postoperative glare and no apparent loss of vision, little or no postoperative discomfort, and infrequent overcorrection. Disadvantages include possible weakening of the integrity of the globe.

References:

1. Boerhaave H. Praelectionespublicae, de morbisoculorum. Göttingen: Abraham Vanden hoeck; 1746.

2. Snellen H. Die richtunge des hauptmeridianedes astigmatishenauges. Albrecht Von Graefes ArchKlinExpOphthalmol1869;15:199-207.

3. Donders FC. On the Anomalies of Accommodationand Refraction of the Eye. London: TheHatton Press; 1864.

4. Leaming DV. Practice styles and preferences of ASCRS membersd1997 survey. J Cataract Refract Surg 1998;24:552-61.

5. Hoffer KJ. Biometry of 7500 cataractous eyes. Am JOphthalmol1980;90:360-8.

6. Lyhne N, Hansen TE, Corydon L. Relationshipbetween preoperative axis of astigmatism and postoperativeastigmatic changes after superior scleral incisionpha coemulsi fication. J Cataract Refract Surg 1998;24: 935-9.

7. Akura J, Matsuura K, Hatta S. A new concept forthe cataract correction of astigmatism: full-arc,depth-dependent astigmatic keratotomy. Ophthalmology2000;107:95-104.

8. Leyland M, ZinicolaE, Bloom P. Prospectiveevaluation of a plate haptic toric intraocular lens. Eye 2001;15:202-5.

9. Lever J, Dahan E.Opposite clear corneal incision to correct pre-existing astigmatism in cataract surgery. J Cataract Refract Surg2001;26:803-5.

10. Gills JP. Cataract surgery with a single relaxing incision at the steep meridian. J Cataract Refract Surg 1994;20:368-9.

11. Budak K, Friedman NJ, Koch DD. Limbal relaxing incisions with cataract surgery. J CataractRefract Surg 1998;24(4):503-8.

12. Guyton DL. Prescribing Cylinders Postoperatively. Year Book Ophthalmol. Chicago: Year Book Medical Publishers; 1985.p.63-6.

13. Lindstrom RL, Lindquist TD. Surgical correctionof postoperative astigmatism. Cornea 1988;7:138-148.

14. Sun XY, Vicary D, Montgomery P.Toric intraocular lenses for correcting astigmatism in 130 eyes. Ophthalmology2000;107:1776-81.

Appendix:

AK = Astigmatic keratotomy
ATR = Against-the-rule
BSCVA = BestSpectacle Corrected Visual Acuity
CCI = Clear Corneal Incision
CRI = Corneal Relaxing Incision
D = Diopter
IOL = Intra Ocular Lens
LRI = Limbal Relaxing Incision
UCVA = Un Corrected Visual Acuity
WTR = With-the-rule

Received date: 20 August 2023
Accepted reviewed version date: 14 April 2024