Original Article

Limbal Relaxing Incision during Phacoemulsification for the Correction of Astigmatism

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Pak J Ophthalmol 2015, Vol. 31 No. 2

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Purpose: To determine the difference in mean post-operative astigmatism of patients having limbal relaxing incisions with phacoemulsification as compared to phacoemulsification alone for the correction of pre-existing corneal astigmatism.

Material and Methods: This study was conducted in the Civil Hospital Karachi Eye Unit II, from 1st December 2009 - 1st December 2010, for duration of 12 months. Patients enlisted for phacoemulsification cataract surgery with co-existing astigmatism were recruited and divided into two groups. Eyes that underwent cataract surgery with limbal relaxing incisions (cataract LRI group) and eyes that underwent cataract surgery only (control group). All patients underwent a comprehensive baseline ophthalmic examination that included uncorrected visual acuity (UCVA) and best corrected visual acuity (BCVA), manifest refraction, anterior segment slit – lamp examination, 90 D examination of fundus, keratometry and ultrasound biometry. Patients were evaluated at 1st day, 1st month and 3rd month postoperatively Post-operative examination included BCVA, anterior segment slit-lamp microscopy and keratometry. The data thus obtained was analyzed on SPSS 17.

Results: A total of 50 eyes (29 right eyes and 21 left eyes) of 44 patients were included in the study. Mean patients age was 61 yrs ± 11.3 yrs (range: 30 to 80) in the LRI group and 57 yrs ± 11.8 yrs (range 30 to 80) in the control group. Data analysis demonstrated statistically significant reduction in the mean post-operative astigmatism in the LRI eyes from 1.78 ± 0.81 D@125º (range: 0.75 to 3.70 D) preoperatively to 0.73 ± 0.71 D @ 130º (range: 0.0 to 2.70) in the 3rd postoperative month as compared to control group from 1.28 ± 0.41 D @ 145º (range: 0.75 to 1.97 D) preoperatively to 1.17 ± 0.57 D @ 144º (range: 0.10 to 2.30) p-value 0.021. There were no intraoperative complications or postoperative subjective complaints (such as halo or glare) in our patients.

Conclusion: Limbal relaxing incisions performed during phacoemulsification surgery appear to be safe and effective procedure to reduce pre-existing corneal astigmatism.

Key Words: Limbal relaxing incision, Phacoemulsification, Astigmatism.

Cataract surgery is the most successful and most commonly performed ophthalmic procedure in the modern medical world.[1,2] An increasingly important goal of modern cataract and lens implantation surgery is to obtain the most desirable refractive outcomes for the patients. As this trend continues, we are faced with addressing the obstacles to spectacle independence. There are an estimated 15 – 20% of individuals with greater than 1.5D of cylinder and a much higher percentage with less than 1.5 D of cylinder.[3] Novel techniques of cataract surgery to correct preexisting astigmatism are presented. Hence, the uncorrected visual outcome of cataract patients has been improved and better

refractive correction is possible now.[4,5] In order to achieve better visual results, the effect of pre-operative corneal astigmatism should be minimized through one of the several techniques including placement of clear corneal incisions(CCI), limbal relaxing incisions (LRI), toric intraocular lens implants (IOL) or postoperative vision correction by ablative refractive surgery by excimer laser; each with its own advantages and disadvantages.[6-8]

Herein, we report the efficacy of limbal relaxing incisions (LRIs) for correction of pre-existing corneal astigmatism during phacoemulsification.

MATERIAL AND METHODS

This study was conducted at the Department of Ophthalmology, Dow University of Health Sciences, Civil Hospital Karachi from 1st December 2009 – 1st December 2010, for duration of 12 months.

Study approval was obtained from the ethics committee of Dow University of Health Sciences and informed consent was obtained from all study participants. Patients admitted in the inpatient department of Ophthalmology Unit 11 Civil Hospital having cataract and co-existing astigmatism of 0.75 D to 3.75 D were selected and randomly divided into two groups.

Inclusion criteria were all patients undergoing cataract surgery from all age groups and from both sexes, patients having pre-existing astigmatism 1 to 3.75 D.

Exclusion criteria was patients having any corneal opacity, degenerations or dystrophies, any retinal vascular diseases or retinal detachment, any macular pathology, glaucoma or patients with any other ocular co-morbidity.

Eyes that underwent cataract surgery with limbal relaxing incisions (cataract LRI group) and eyes that underwent cataract surgery only (control group). Fifty eyes of forty four patients (mean age 59 years ± 11.6 range 30 to 80 years) were included. Youngest patient was 30 years while the oldest being 80 years of age.

All patients underwent a comprehensive baseline ophthalmic examination that included uncorrected visual acuity (UCVA) and best corrected visual acuity (BCVA), manifest refraction, anterior segment slit-lamp examination, 90 D examination of fundus, keratometry and ultrasound biometry. Patients were evaluated at 1st day, 1st month and 3rd month postoperatively Post-operative examination included UCVA, anterior segment slit-lamp microscopy and keratometry.

All surgeries were performed by one surgeon. SRK-T formula was used for all patients for IOL power calculation. Cataract surgery was performed under topical anesthesia. Acrylic foldable IOLs (Alcon, SA 60 AT, USA) were implanted through a 2.75 mm temporal clear corneal incision in R eyes and nasal in L eyes without enlarging the incision using the injector for all eyes.

In the cataract LRI group before surgery, the steepest meridian was marked with the patient in supine position based on corneal topography on which LRIs were made according to the Nichamin nomogram (Table 2).

All LRIs were placed inside the surgical limbus at a depth of 600 µm with LRI knife determined for 600 µm.

For patients with against-the-rule astigmatism the temporal hinge incision for phacoemulsification was oriented to align with placement of the LRI. A second LRI was performed on the nasal side before phacoemulsification. After IOL implantation and before removal of viscoelastic material, the original minimal LRI was extended according to the nomogram. In eyes with the rule astigmatism, paired LRIs were placed on the steep meridian before phacoemulsification as dictated by the nomogram.

The collected data was analyzed by using SPSS version 17.0. The results of the study were presented through tables. The success of the procedure was evaluated by comparing pre- and post-operative keratometry readings. Effectiveness was analysed by comparing the arithmetic mean and standard deviation of the post-operative keratometric astigmatism between the groups. Independent sample t-test was used to check the difference between the two groups with level of significance of ≤ 0.5.

All post-operative complications and subjective symptoms were recorded. Stratification was done to age and gender to see the impact of these on the outcome.

RESULTS

LRI with phacoemulsification was performed on 25 eyes whereas 25 eyes underwent phacoemulsification alone. Total of 50 eyes were included (29 right eyes and 21 left eyes) of 44 patients. There was no significant difference in the mean age of the patients in

the two groups. Mean age was 61 years ± 11.3 yrs (range: 30 to 80) in the LRI group and 57 years ± 11.8 years (range 30 to 80) in the control group.

Table 1: Comparison of Mean Astigmatism.

	Pre-operative Astigmatism	Post-operative Astigmatism
LRI	1.78 ± 0.81 @ 125°	0.73 ± 0.71 @ 130°
CONTROL	1.28 ± 0.41 @ 145°	1.17 ± 0.57 @ 144°

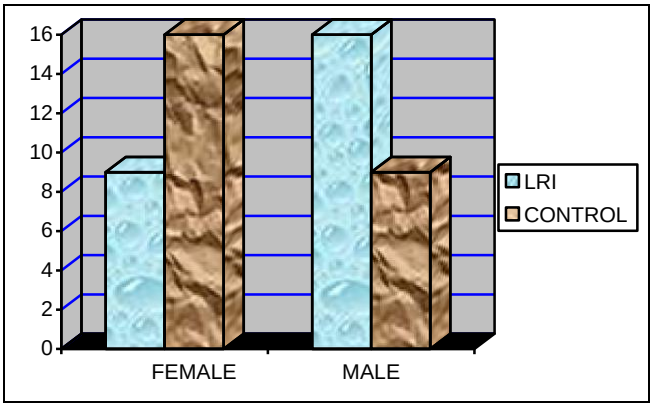

Fig. 1: Gender distribution in cases (n = 50).

Out of 25 patients of LRI group nine (2.25%) were females and sixteen (4%) were males whereas in the control group sixteen (4%) were females and nine (2.25%) were males.

Data analysis demonstrated statistically significant reduction in the mean post-operative astigmatism in the LRI eyes as compared to control group.

Mean decrease in the LRI group was 1.04 ± 0.87 D while in the control group was 0.10 ± 0.53 D._LRI group showed reduction from 1.78 ± 0.81 D @ 125^0 (range: 0.75 to 3.70 D) preoperatively to 0.73 ± 0.71 D @ 130° (range: 0.0 to 2.70 D) in the 3rd postoperative month whereas the control group showed reduction from 1.28 ± 0.41 D @ 145° (range: 0.75 to 1.97 D) preoperatively to 1.17 ± 0.57 D @ 144° (range: 0.10 to 2.30 D) in the 3rd postoperative month p-value 0.021.

There were no intraoperative complications or postoperative subjective complaints (such as halo or glare) in our patients.

DISCUSSION

Visual recovery and satisfaction of patients who underwent phacoemulsification is closely related to the appropriate IOL power calculation and management of postoperative astigmatism.[9-11] Among patients undergoing cataract surgery, 15 - 20% have significant corneal astigmatism ranging from 1 to 3 D. With the introduction of aspherical intraocular lens (IOLs) as an integral part of cataract surgery, better formulae for IOL power calculation, and eliminating lenticular astigmatism by removing the lens by cataract extraction, the major source of postoperative refractive astigmatism is the corneal astigmatism.

There are several options to reduce the pre-operative astigmatism including intraoperative relaxing incisions, toric IOL implantation or postoperative vision correction by ablative refractive surgery by excimer laser each with its own benefits and drawbacks. Toric IOLs are rather expensive. Moreover, if postoperative rotation of the IOL occurs, there would be a significant induced astigmatism. Excimer laser vision correction after cataract surgery needs an additional operation with high expenses, possible complications and limitations in patients with thin cornea.[12-13]

LRIs have been used to correct preexisting astigmatism at the time of cataract surgery. Simultaneously, one can benefit from lower costs and easy performance with minimal learning curve, without overcorrection. However, the predictability, stability and range of correction are rather limited.

According to Gills and Guyton LRIs are more effective in eyes with low to moderate, rather than high astigmatism. LRIs also appear to cause less distortion and irregularity at the limbus. They can provide more rapid postoperative visual acuity (VA) as compared to clear corneal incisions with less risk of glare and discomfort.

In this study, the use of limbal relaxing incisions during phacoemulsification significantly reduced pre-existing corneal astigmatism. Astigmatism correction is evaluated by comparing the pre-operative and post-operative mean keratometry Effectiveness of LRI'S was evaluated by using mean and standard deviation of the post-operative astigmatism between the groups.

Based on the results obtained we reject the null hypothesis which stated that there was no difference in the mean post-operative astigmatism of patients having LRI with phacoemulsification as compared to phacoemulsification alone.

Phacoemulsification and lens implantation were performed through a 2.75mm temporal incision to

Table 2: Nichamin Nomogram.

Astigmatic status = "spherical": (+0.75 × 90° to +0.50 × 180°)

Incision design = "neutral" temporal clear corneal incision (3.5 mm or less, single plane, just anterior to vascular arcade)

Against-the-rule astigmatism — steep axis 0°-30°/150°-180°

Intraoperative keratoscopy determines exact incision location

Preop cylinder		Years old 30-40	41-50	51-60	61-70	71-80	81-90	>90
+0.75 to +1.25	nasal limbal arc only					35°		
	*paired limbal arcs	55°	50°	45°	40°	35°	on steep axis	
+1.50 to +2.00	*paired limbal arcs on steep axis	70°	65°	60°	55°	45°	40°	35°
+2.25 to +2.75	*paired limbal arcs on steep axis	90°	80°	70°	60°	50°	45°	40°
+3.00 to +3.75	*paired limbal arcs on steep axis	reduce oz to 8 mm 90°	reduce oz to 8 mm 90°	85°	70°	60°	50°	45°

Degrees of arc to be incised

**The temporal incision is made by first creating a two-plane, grooved phaco incision (600 µm depth), which is then extended to the appropriate arc length at the conclusion of surgery.*

Source: Nichamin LD

With-the-rule astigmatism — steep axis 45°-145°

Intraoperative keratoscopy determines exact incision location

Incision design = "neutral" temporal clear corneal along with the following peripheral arcuate incisions

Preop cylinder		Years old 30-40	41-50	51-60	61-70	71-80	81-90	>90
+1.00 to +1.50	paired limbal arcs on steep axis	50°	45°	40°	35°	30°		
+1.75 to +2.25	paired limbal arcs on steep axis	60°	55°	50°	45°	40°	35°	30°
+2.50 to +3.00	paired limbal arcs on steep axis	70°	65°	60°	55°	50°	45°	40°
+3.25 to +3.75	paired limbal arcs on steep axis	80°	75°	70°	65°	60°	55°	45°

Degrees of arc to be incised

avoid inducing astigmatism. According to Fine[14] a temporal incision might minimize the astigmatism induced by phacoemulsification due to a number of factors such as an incision architecture that maximizes the distance from the limbus to the central cornea, the lack of action of the superior rectus muscle, and the alignment of the incision with the action of superior eyelid and gravitational pull.

Induced astigmatism is likely related to the creation and manipulation of the incision during surgery.[15] Induction of astigmatism may be averted by prevention of thermal damage to the incision by the phaco tip and the correct IOL implantation.[16-19]

Our study demonstrated that use of LRIs during phacoemulsification significantly reduces corneal astigmatism; however, there was a trend for under correction. Under correction was not uncommon in previous reports.[20-21] Budak et al, studied 22 patients. They found a 44% reduction of astigmatism in eyes treated with LRI during phacoemulsification using the Gills nomogram.[22] In another study of 12 eyes of 11 patients that underwent phacoemulsification and limbal relaxing incision Budak et al, found 75% of the eyes were under corrected.

In study of Carvalho et al,[9] a statistically significant reduction in the mean topographic astigmatism was seen in the cataract LRI eyes from 1.93 ± 0.58 D preoperatively to 1.02 ± 0.60 D 6 months postoperatively ($P < 0.05$).

Multiple factors might cause under correction of astigmatism in patients who are treated with phacoemulsification and LRIs. We minimized the surgeon factor by performing all operations by only one surgeon. Another cause may be the improper position of blade (Oblique incision rather than perpendicular incision on the limbus, that may result in the wrong depth causing under correction).[23] Under correction may be related to area of limbal incision that is far from the corneal center.[24] However, more central clear corneal incisions may cause more glare and higher order aberrations for the patients.

In summary, when combined with the accurate identification of the steep meridian of corneal astigmatism, limbal relaxing incisions are safe and efficacious for correcting corneal astigmatism during phacoemulsification.

CONCLUSION

In our study 25 eyes that were operated with LRIs during phacoemulsification surgery. Limbal Relaxing incisions appear to be safe and fairly effective to correct mild to moderate amounts of corneal astigmatism. Under correction is a common limitation that may be further managed by modified nomograms in future studies adjusted by the surgeon factors. Apart from the patient age, multiple factors including ethnicity, gender, corneal limbal thickness, course of postoperative steroid regimen and surgeon factors should be considered for adjustment of future nomograms.

It seems that LRI incisions cannot fully correct but would cause more acceptable reduction in the preoperative corneal astigmatism.

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REFERENCES

1. **Kershner RM.** Refractive Cataract Surgery. Curr Opin Ophthalmol. 1998; 9: 46-54.
2. **Nichamin LD.** Treating astigmatism at the time of cataract surgery. Curr Opin Ophthalmol. 2003; 14: 35-8.
3. **Hoffer KJ.** Biometry of 7,500 cataractous eyes. Am J Ophthalmol. 1980; 90: 360-8.
4. Nichamin LD. Astigmatism control. Ophthalmol Clin North Am. 2006; 19: 485-93.
5. **Alastrué V, Calvo B, Peña E, Doblaré M.** Biomechanical modeling of refractive corneal surgery. J Biomech Eng. 2006; 128: 150-60.
6. **Morlet N, Minassian D, Dart J.** Astigmatism and the analysis of its surgical correction. Br J Ophthalmol. 2001; 85: 1127-38.
7. **Kaufmann C, Peter J, Ooi K , Phipps S, Cooper P, Goggin M, et al.** Limbal relaxing incisions versus on axis incision to reduce corneal astimatism at the time of cataract surgery. J Cataract Refract Surg. 2005; 31: 2261-5.
8. **Carvelho MJ, Suzuki SH, Freitas LL, Branco BC, Schor P, Lima AL.** Limbal relaxing incision to correct corneal astigmatism during phacoemulsification. J Refract Surg. 2007; 23: 499-504.
9. **Oshika T, Yoshitomi F, Fukuyama M, Hara Y, Shimokawa S, Shiwa T, Sakabe I.** Radial keratotomy to treat myopic refractive error after cataract surgery. J Cataract Refract Surg. 1999; 25: 50-5.
10. **Packer M, Fine IH, Hoffman RS, Coffman PG, Brown LK.** Immersion A-scan compared with partial coherence interferometry: outcomes analysis. J Cataract Refract Surg. 2002; 28: 239-42.

11. **Murphy C, Tuft SJ, Minassian DC.** Refractive error and visual outcome after cataract extraction. J Cataract Refract Surg. 2002; 28: 62-6.
12. **Bayramlar HH, Daglioglu MC, Borazan M.** Limbal relaxing incisions for primary mixed astigmatism and mixed astigmatism after cataract surgery. J Cataract Refract surg. 2003; 29: 723-8.
13. **Gills JP, Gayton JL.** Reducing pre-existing astigmatism. In: Gills JP, Fenzle R, Martin RG, eds, cataract surgery; the state of the art. Thorofare, NJ, Slack. 1998; 53-66.
14. **Fine IH.** Architecture and construction of a self sealing incision for cataract surgery . J Cataract Refract Surg. 1991; 17: 672-6.
15. **Steinert RF, Deacon J.** Enlargement of incision width during phacoemulsification and folded intraocular lens implant surgery. Opthalmology. 1996; 103: 220-5.
16. **Majid MA, Sharma MK, Harding SP.** Corneosclral burn during phacoemulsification surgery. J Cataract Refract Surg. 1998; 24: 1413-5.
17. **Sugar A, Schertzer RM.** Clinical course of phacoemulsification wound burns. J Cataract Refract Surg. 1999; 25: 688-92.
18. **Mamalis N.** Incision width after phacoemulsification with foldable intraocular lenses. J Cataract Refract Surg. 2000; 26: 237-41.
19. **Kohen T, Lambert RJ, Koch DD.** Insicion sizes for foldable intraocular lenses. Ophthalmol. 1997; 104: 1277-86.
20. **Osher RH.** Paired transverse relaxing keratotomy: a combined technique for reducing astigmatism. J Cataract Refract Surg. 1989; 15: 32-7.
21. **Oshika T, Shimazaki J, Yoshitomi F, Oki K, Sakabe I, Matsuda S, et al.** Arcuate keratotomy to treat corneal astigmatism after cataract surgery: a prospective evaluation of predictability and effectiveness. Ophthalmology. 1998; 105: 2012-6.
22. **Budak K, Yilmaz G, Aslan BS, Duman S.** Limbal relaxing incisions in congenital astigmatism: 6 month follow-up. J Cataract Refract Surg. 2001; 27: 715-9.
23. **Akura J, Matsuura K, Hatta S, Otsuka K, Kaneda S.** A new concept for the correction of astigmatism: full-arc, depth – dependent astigmatic keratotomy. Ophthalmology, 2000; 107: 95-104.
24. **Waring Go 3rd, Lynn MJ, McDonnell PJ.** Results of the prospective evaluation of radial keratotomy (PERK) study 10 years after surgery. Arch Opthalmol. 1994; 112: 1298-308.