Limbal Relaxing Incision during Phacoemulsification for the Correction of Astigmatism

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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@125° (range: 0.75 to 3.70 D) preoperatively to 0.73 ± 0.71 D @ 130° (range: 0.0 to 2.70) in the 3rd postoperative month as compared to control group 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) 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.
refractive correction is possible now. 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.

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 1\textsuperscript{st} December 2009 – 1\textsuperscript{st} 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 1\textsuperscript{st} day, 1\textsuperscript{st} month and 3\textsuperscript{rd} 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 keratometric 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.

<table>
<thead>
<tr>
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<th>Pre-operative Astigmatism</th>
<th>Post-operative Astigmatism</th>
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<tbody>
<tr>
<td>LRI</td>
<td>1.78 ± 0.81 @ 125°</td>
<td>0.73 ± 0.71 @ 130°</td>
</tr>
<tr>
<td>CONTROL</td>
<td>1.28 ± 0.41 @ 145°</td>
<td>1.17 ± 0.57 @ 144°</td>
</tr>
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</table>

**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° (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. 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 preoperative 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.

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 LRIs 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**

<table>
<thead>
<tr>
<th>Preop cylinder</th>
<th>30-40</th>
<th>41-50</th>
<th>51-60</th>
<th>61-70</th>
<th>71-80</th>
<th>81-90</th>
<th>&gt;90</th>
</tr>
</thead>
<tbody>
<tr>
<td>+0.75 to +1.25</td>
<td>55°</td>
<td>50°</td>
<td>45°</td>
<td>40°</td>
<td>36°</td>
<td>35°</td>
<td></td>
</tr>
<tr>
<td>+1.50 to +2.00</td>
<td>paired limbal arcs 70°</td>
<td>65°</td>
<td>60°</td>
<td>55°</td>
<td>45°</td>
<td>40°</td>
<td>35°</td>
</tr>
<tr>
<td>+2.25 to +2.75</td>
<td>paired limbal arcs 90°</td>
<td>80°</td>
<td>70°</td>
<td>60°</td>
<td>50°</td>
<td>45°</td>
<td>40°</td>
</tr>
<tr>
<td>+3.00 to +3.75</td>
<td>paired limbal arcs reduce oz to 8 mm</td>
<td>reduce oz to 8 mm</td>
<td>85°</td>
<td>80°</td>
<td>60°</td>
<td>50°</td>
<td>45°</td>
</tr>
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</table>

**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**

<table>
<thead>
<tr>
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<th>51-60</th>
<th>61-70</th>
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<th>81-90</th>
<th>&gt;90</th>
</tr>
</thead>
<tbody>
<tr>
<td>+1.00 to +1.50</td>
<td>paired limbal arcs on steep axis</td>
<td>50°</td>
<td>45°</td>
<td>40°</td>
<td>35°</td>
<td>30°</td>
<td></td>
</tr>
<tr>
<td>+1.75 to +2.25</td>
<td>paired limbal arcs on steep axis</td>
<td>50°</td>
<td>55°</td>
<td>50°</td>
<td>45°</td>
<td>40°</td>
<td>35°</td>
</tr>
<tr>
<td>+2.50 to +3.00</td>
<td>paired limbal arcs on steep axis</td>
<td>50°</td>
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<td>45°</td>
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<td>45°</td>
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**Degrees of arc to be incised**
avoid inducing astigmatism. According to Fine\textsuperscript{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.\textsuperscript{15} Induction of astigmatism may be averted by prevention of thermal damage to the incision by the phaco tip and the correct IOL implantation.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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,\textsuperscript{9} a statistically significant reduction in the mean topographic astigmatism was seen in the cataract LRI eyes from $1.93 \pm 0.58$ D preoperatively to $1.02 \pm 0.60$ 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).\textsuperscript{23} Under correction may be related to area of limbal incision that is far from the corneal center.\textsuperscript{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**


