# Limbal Relaxing Incisions versus Penetrating Limbal Relaxing Incisions for the Management of Astigmatism in Cataract Surgery

## Abstract

**Purpose:** To compare between Limbal relaxing incisions and Penetrating limbal relaxing incisions in the management of astigmatism during cataract surgery.

**Setting:** Cairo university hospitals (Kasr EL-Aini; Ophthalmic surgical unit).

**Methods:** This prospective study was divided into two groups, group A; 20 cases LRIs and group B; 20 cases PLRIs. Limbal relaxing incisions were performed following the DONO nomogram during phacoemulsification using a preset guarded 550 microns disposable blade. Penetrating limbal relaxing entailed performing two full thickness incisions using a keratome knife along the steepest corneal meridian, in addition to the clear corneal stab incision of the phacoemulsification following the Mackool nomogram.

**Results:** 40 eyes were evaluated. At 1 month postoperative, the average change in corneal cylinder (Δchange) was found to be 1.178 D, SD 0.338 in the LRI group and -0.095 D, SD 0.846 in the PLRI group.

**Conclusion:** The use of LRIs has been shown to be extremely safe and reliable. In the setting of concomitant lens surgery, our data indicate that this technique provides more predictable astigmatic outcomes as compared to the use of PLRIs, and yields more consistent results than when relying solely upon a tailored phaco incision.

**Keywords:** LRIs; PLRIs; Astigmatism; Corneal topography

Research Article

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**Abbreviations:** LRIs: Limbal Relaxing Incisions; PLRIs: Penetrating Limbal Relaxing Incisions; CDVA: Corrected Distance Visual Acuity; IOP: Intraocular Pressure; PRK: Photorefractive Keratotomy; LASIK: Laser In Situ Keratomileusis

## Introduction

Incisional surgical correction of astigmatism can be performed as part of cataract surgery to optimize the refractive and visual outcome for cataractous cases with preexisting corneal astigmatism [1]. There is still no standard surgical approach and numerous surgical options are available. "Limbal relaxing incisions" (LRIs) during phacoemulsification in addition to the clear corneal stab incision of phacoemulsification is one option. Other options include placement of phacoemulsification incision on the steep corneal meridian, excimer laser ablation for postoperative astigmatism and toric intraocular lens implantation [2-7].

Recently the concept of penetrating limbal relaxing incisions (PLRIs) was introduced by Richard Mackool et al. [5,8,9]. Penetrating limbal relaxing incisions entail performing two full thickness incisions using a keratome knife along the steepest meridian, in addition to the clear corneal stab incision of the phacoemulsification. Penetrating limbal relaxing incisions are simpler; do not require special instrumentation as in limbal relaxing incisions.

## Patients and Methods

A prospective randomized comparative analysis was performed at ophthalmic surgical unit of Kasr El-Aini Teaching Hospital; Cairo university. Informed consent was obtained from all patients before surgery. Inclusion criteria included patients aged20-80 years, both sexes enrolled, Topographic astigmatism 1.0-4.0 diopters, clear cornea. Exclusion criteria included preexisting ocular condition as corneal opacities, keratoconus, glaucoma, uveitis, retinal and optic nerve disease. Topographic astigmatism <1.0 diopter or more than 4.0 diopters.

All patients had a standard ophthalmic examination that included corrected distance visual acuity (CDVA), Refraction, intraocular pressure (IOP) measurement; slit lamp examination, fundoscopic evaluation. Corneal topography was performed using a placido disc based Shin-Nippon CT-1000 topography machine (Shin-Nippon, Tokyo). All surgeries were performed under local peribulbar anaesthesia using Xylocaine 1% and Bupivacaine 5%, the lens nucleus was fragmented using stop and chop technique.

For LRI technique, we used the Katena Chu LRI marker (Katena, Denville, USA) and the Mendez ring manufactured by Duckworth and Kent (England, UK) to mark the incision before performing it. For the incisions performed in this study, we used the preset guarded stainless steel knifes with preset guards of

550 µm depth (Micro feather 550 microns, blade number 7355G, Oasis medical, CA, USA). The LRIs were performed before making the phaco incision, but after wetting the cornea. Marking of the steep axis using the Mendez ring, a Johnson and Johnson marker pen and a fixation forceps. Paint the segment in the Chu marker that corresponds to the proper arc length of the LRI incision according to the preoperative corneal cylinder. Mark the cornea using the Chu marker centralized on the axis mark previously performed leaving clear stained incision marks on the cornea 1-1.5 mm inside the limbus. With the aid of a fine 0.12 fixation callibri forceps, the conjunctiva is grasped and the eye fixated.

The guarded knife is inserted at one end of the incision mark, as perpendicular to the corneal surface as possible, then advanced along the preset incision mark to complete the LRI trying at all times to maintain its perpendicular orientation. Incisions are typically paired to optimize symmetric corneal flattening and expressed in degrees of arc rather than millimeters since corneal diameter may significantly impact the relative length of the arcuate incision and its resultant effect (as proposed by the LRI calculator software). For PLRI technique2 MVR incisions using MVR 19 gauge were performed along the steepest meridian guided by preoperative corneal topography. Keratome incision using keratome 3.2mm was performed 90 degrees from the side ports. After IOL implantation the 2 side ports were enlarged to the desired length according to Mackool nomogram. Incisions were checked for leakage.

All patients received an AcrySof IQ SN6OWF implant (Alcon, TX, USA). During the first month postoperative, all patients received a combined antibiotic-corticosteroid agent. Patients were examined 1, 7 and 30 days after surgery. Follow-up examinations included CDVA, IOP, biomicroscopic anterior chamber evaluation, and fundoscopic evaluation. Corneal topography was done for all patients at 1 month postoperative. Non-parametric t test (called Mann Whitney test) was used for comparing means. A Q-Q plot was used to test normality, and data were not found to be normally distributed. Also a histogram for each variable was constructed to visualize the distribution with normal curve overhead to compare. SPSS V 12.0 was used for data analysis.

## LRI Nomogram

For our LRI group of patients we planned our LRIs according to the AMO LRI calculator software version 4.4. This is free online software offered by AMO (www.lricalculator.com) (Figure 1). In this software, two main nomograms are offered, the DONO nomogram designed by Dr. Eric Donnenfeld (NYU, USA) which is simple, and easy to use without a lot of Add-ones. The other nomogram offered by the LRI calculator software is the NAPA nomogram (referring to the Nichamin age and pachymetry adjusted nomogram). In our study we used the DONO nomogram due to its simplicity and to avoid performing peripheral corneal pachymetry for all patients included.

Each patient data was fed into the software and the number and length of LRI needed was predicted by the software, minor modifications were done to the nomogram as recommended by the software developers. We increased the calculated LRI length by 5 degrees for against the rule astigmatism. We increased the calculated LRI length for younger patients (less than 30 years). We decreased the calculated LRI length for older patients (more than 70 years).

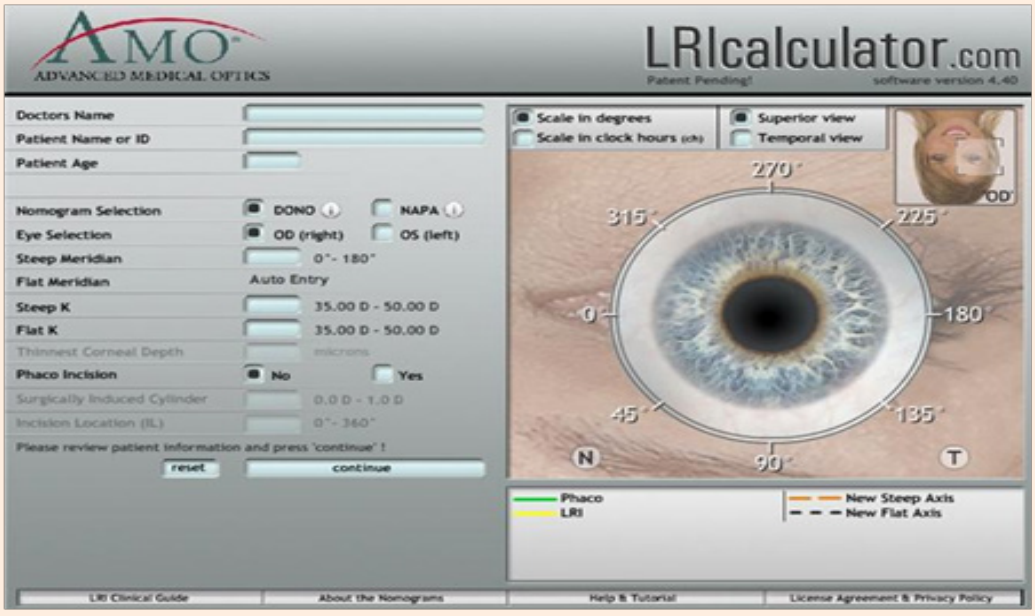


**Figure 1:** AMO LRI calculator.

## PLRI Nomogram

As proposed by Mackool R [8,9] we followed his nomogram for penetrating limbal relaxing incisions for alleviating preoperative astigmatism during cataract surgery as detailed in (Table 1). In the LRI group, the preoperative steep meridian was vertical in 8 cases (40%), and horizontal in 12 cases (60%) which changed postoperative to 10 cases vertical and 10 cases horizontal. In the PLRI group, the preoperative steep meridian was vertical in 10 cases (50%), and horizontal in 10 cases (50%) which changed postoperative to 8 cases vertical and 12 cases horizontal.

Table 2 In the LRI group, the phaco incision was vertical in all 20 cases. In the PLRI group, the phaco incision was vertical in 10 cases and horizontal in 10 cases. In the LRI group, mean cylinder preoperative was 1.8 D (SD range 0.636) however mean cylinder postoperative was 0.62 D (SD range 0.421). In the PLRI group, mean cylinder preoperative was 1.6 D (SD range 0.619) however mean cylinder postoperative was 1.7 D (SD range 0.798). (Table 3, Figure 2). The average change in corneal cylinder (Δchange) was found to be 1.178 D, SD 0.338 in the LRI group and -0.095 D, SD 0.846 in the PLRI group showing an increase postoperative.

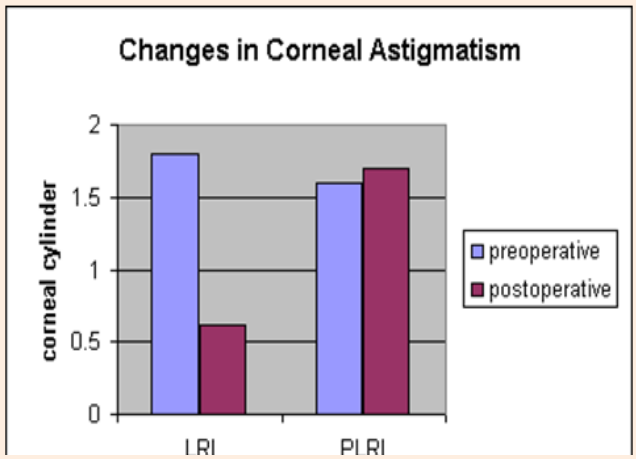


**Figure 2:** Changes in corneal astigmatism.

**Table 1:** Mackool nomogram for PLRIs.

| Effect of Horizontal PLRI(s) | | |
|---|---|---|
| **Length** | **Mean (Range) 1 Incision** | **Mean (Range) 2 Incisions** |
| 2.75 | 0.3 (0-5) | 0.7 (0-1.1) |
| 3.0 | 0.4 (0-7) | 1.1 (0-1.8) |
| 3.2 | 0.6 (0-1.0) | 1.5 (0-2.1) |

| Effect of Vertical PLRI(s) | | |
|---|---|---|
| **Length** | **Mean (Range) 1 Incision** | **Mean (Range) 2 Incisions** |
| 2.75 | 0.4 (0-8) | 1.0 (0-1.5) |
| 3.0 | 0.6 (0-1.0) | 1.4 (0-2.0) |
| 3.2 | 0.8 (0-1.2) | 1.8 (0-2.4) |

**Table 2:** Shows the patients' characteristics. Forty patients (20 cases in LRI group and 20 cases in PLRI group) were enrolled in the study.

| | | Groups | | | |
|---|---|---|---|---|---|
| | | LRI | | PLRI | |
| | | Count | Col % | Count | Col % |
| Sex | M | 10 | 50.0% | 9 | 45.0% |
| | F | 10 | 50.0% | 11 | 55.0% |

| | Groups | N | Mean | SD. | p Value |
|---|---|---|---|---|---|
| Age | LRI | 20 | 62.40 | 5.175 | |
| | PLRI | 20 | 46.80 | 16.087 | < 0.001 |

| | | Groups | | | |
|---|---|---|---|---|---|
| | | LRI | | PLRI | |
| | | Count | Col % | Count | Col % |
| OD/OS(1/2) | OD | 10 | 50.0% | 10 | 50.0% |
| | OS | 10 | 50.0% | 10 | 50.0% |

| | | | Groups | | Total |
|---|---|---|---|---|---|
| | | | LRI | PLRI | |
| Cataract Grade | Nuclear II | Count | 12 | 15 | 27 |
| | | % within groups | 60.0% | 75.0% | 67.5% |
| | Nuclear III | Count | 8 | 0 | 8 |
| | | % within groups | 40.0% | .0% | 20.0% |
| | Post. Subcapsular | Count | 0 | 5 | 5 |
| | | % within groups | .0% | 25.0% | 12.5% |
| Total | | Count | 20 | 20 | 40 |
| | | % within groups | 100.0% | 100.0% | 100.0% |

**Table 3:** Changes in corneal astigmatism.

| Corneal Cylinder | LRI Group | PLRI Group |
|---|---|---|
| Preoperative | Mean 1.8 D, SD 0.63 | Mean 1.6 D, SD 0.61 |
| Postoperative | Mean 0.62 D, SD 0.42 | Mean 1.7 D, SD 0.79 |

## Discussion

Preexisting corneal astigmatism at the time of cataract surgery can be treated by manipulation of cataract incision, limbal relaxing incisions (LRIs), astigmatic keratotomy, paired opposite clear corneal incision, implantation of toric intraocular lens, photorefractive keratotomy (PRK), laser in situ keratomileusis (LASIK) and recently penetrating limbal relaxing incisions (PLRIs) [10,11]. There are several approaches for reducing preexisting astigmatism during cataract surgery; perhaps the most basic is placement of incision along the steep corneal meridian taking the advantage of wound induced flattening. There are two major limitations of this approach. First with small incisions the with the rule flattening is insufficient

to correct existing astigmatism in excess of approximately 1.00 D. Second, centering the incision on certain meridians is techniqually difficult (e.g. superonasal or inferotemporal in left eye) [12].

Limbal relaxing incisions are an effective way to reduce astigmatism at the time of cataract surgery. No adjustment to the surgeon's preferred position of the cataract incision is needed with LRIs. Due to their placement at the outermost periphery of the cornea and their similarity to conventional cataract incisions, these incisions are simple to perform and unlikely to cause complications. The forgiving nature of the procedure represents another advantage. Disadvantage of the LRI includes requiring special instrumentation (diamond knife, or preset depth guarded disposable blades), possible weakening of the integrity of the globe and moderate variability in accuracy, presumably resulting from variations in individual wound healing pattern. LRIs can correct astigmatism up to 4 diopters [11,13,14]. LRIs leave the central cornea untouched for other corneal refractive interventions for residual ametropia. We believe that excimer laser procedures (LASIK) can be used for cases with under corrections after LRIs [15-17].

In our study, we decided to perform LRIs just before the phaco procedure for two reasons, first, as pressure on the posterior lip of the clear corneal incision leads to wound leakage and variable IOP which may lead to variable depth of the LRIs. Second, there might be greater variability in corneal thickness from intraoperative corneal edema. To our advantage these LRIs did not lead to corneal haze that interfered with phaco surgery as the incisions were placed in the most peripheral cornea as reported by other studies [18]. In our study, in the LRI group we found that the mean preoperative astigmatism was 1.8 D, mean postoperative astigmatism was 0.62 D with a mean cylinder absolute change of 1.178 D and a percentage drop of 67.04%. At the end of the follow-up period out of 20 eyes, 10 eyes are left with 0.5 D corneal astigmatism, 4 eyes with 0.25 D corneal astigmatism, 2 eyes with 0.75 D, 1 eye with 0.63 D, 1 eye with 1 D, 1 eye with 1.3 D and 1 eye with 2.0 D. There were no significant effects of age and sex on results as evident by correlation tests. In our study, there were no ocular perforations suggesting a good safety profile for using a guarded disposable stainless steel knife set at a depth of 550 micrometer.

In the PLRI group we found that the mean preoperative astigmatism was 1.6 D, mean postoperative astigmatism was 1.7 D with a mean cylinder absolute change of -0.095 D and a percentage drop of -14.23 % so PLRI did not reduce astigmatism but in our study the astigmatism increased after PLRIs but the increase was minimal and insignificant. PLRIs were proposed as a mean of reducing preexisting corneal astigmatism during cataract surgery due to its simplicity (2 full thickness keratome incisions similar to phaco incision), easy to perform, do not require special skills and do not require special instrumentation compared to LRIs, however results showed that PLRIs are ineffective in reducing preexisting corneal astigmatism [8,9]. Obviously, the penetrating nature of PLRIs raises the question of their safety. Nichamin considered it improper or at least excessive to place additional penetrating incisions if they can be avoided, particularly if a nomogram is devised such that penetrating incisions are to be lengthened to correct higher levels of astigmatism [19]. In our study, the PLRIs were not sutured. The unused incisions were always well sealed; the incisions used during the procedure were always hydrated for sealing. We did not encounter any case of wound gap or leak postoperatively. No postoperative infection was observed.

We believe that the limitation of our study lies in the fact that the mean age of both groups was not the same, the PLRI group was significantly lower. The aim of our study was to compare between limbal relaxing incisions (LRIs technique) and penetrating limbal relaxing incisions (PLRIs technique) as regards the simplicity and efficacy in the treatment of preexisting corneal astigmatism at the time of cataract surgery.

## Summary

Use of LRIs has been shown to be extremely safe and reliable. In the setting of concomitant lens surgery, our data indicate that this technique provides more predictable astigmatic outcomes as compared to the use of PLRIs, and yields more consistent results than when relying solely upon a tailored phaco incision.

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