Original Article

Toric Intraocular Lens vs. Peripheral Corneal Relaxing Incisions to Correct Astigmatism in Eyes Undergoing Cataract Surgery

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Abstract

Purpose: To compare toric intraocular lens implantation (Toric-IOL) with peripheral corneal relaxing incisions (PCRIs) for astigmatism correction in patients undergoing cataract surgery.

Methods: 54 patients (54 eyes) with more than 0.75 diopter (D) of preexisting corneal astigmatism were classified as group A (0.75–1.50D) or group B (1.75–2.50D). The patients were randomized to undergo Toric-IOL or PCRIs in the steep axis with spherical IOL implantation. LogMAR uncorrected visual acuity (LogMAR UCVA), LogMAR best corrected vi sual acuity (LogMAR BCVA), error of vector (|EV|), surgery induced refraction correction (|SIRC|), and correction rates (CR) were measured 1 month and 6 months postoperatively.

Results: At 6 months postoperatively, all 54 eyes had LogMAR BCVA≤0.2. Patients who underwent PCRIs and Toric-IOL with LogMAR BCVA≤0.1 showed no significant differences in group A (P=1.00) or in group B (P=0.59). Group A showed no significant differences in LogMAR UCVA (P=0.70), |EV| (P=0.13), |SIRC| (P=0.71), and CR (P=0.56) in patients underwent PCRIs and Toric-IOL. However, group B showed significant differences in LogMAR UCVA (P<0.01), |EV| (P<0.01)), |SIRC| (P<0.01), and CR (P<0.01). The LogMAR UCVA and |EV| between 1 and 6 months showed no significant differences in patients in group A. However, in group B, they are significant differences.

Conclusion: The efficacy and stability of Toric-IOL and PCRIs were equal in low astigmatic patients. Toric-IOL achieved an enhanced effect over PCRIs in higher astigmatic patients. PCRIs had the more refractive regression than Toric-IOL in 6 months. (***Eye Science 2014; 29:198–203***)

Keywords: toric intraocular lens; peripheral corneal relaxing incision; astigmatism; cataract; surgery

Introduction

Cataracts are globally a common and significant cause of visual impairment. The main cause of the formation of cataracts is age, but they can also arise due to congenital diseases, inherited abnormalities, trauma, ocular and systemic diseases, and systemic medications (steroids and phenothiazines). Cataract surgery is one of the most commonly performed surgeries in the world. The prevalence of cataract increases with age, from 16% in the 65 to 69 age group to 71% in those aged 85 years or more; it also tends to affect women more than men[1].

Astigmatism occurs when the patient's cornea is steeper in the vertical axis (regular astigmatism) or in the horizontal axis (irregular astigmatism) when the principal meridians are perpendicular[2]. A third type of regular astigmatism, oblique astigmatism, occurs when the steepest curve lies between 10°–150° and 30°–60°. When replacing a lens during cataract surgery, astigmatism can either be corrected by prescription glasses, contact lenses, corneal relaxing incisions, astigmatic keratotomies, limbal relaxing incisions, excimer laser ablation, or toric intraocular lens implantation[3].

Astigmatism and cataracts reduce the quality of life of a patient[4,5]. Cataract surgery has shifted from

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cataract refractive surgery to spherical mirror refraction of cataract surgery for accurate forecasting and control due to the reduction in the incision for phacoemulsification and improvements in the materials and designs of intraocular lenses, as well as biological improvements of in the accuracy of measurement of the eyeball[6,7]. Preoperative corneal astigmatism in cataract patients has become an important factor in naked eye vision after surgery. Toric-IOL implantation and corneal incision are currently two main methods for correction of astigmatism in patients before cataract surgery[8-10]. In this study, we aimed to compare toric intraocular lens implantation (Toric-IOL) with peripheral corneal relaxing incisions (PCRIs) for astigmatism correction in patients undergoing cataract surgery.

Subjects and methods

Patients, selection criteria, and exclusion criteria

In total, 54 patients (54 eyes) with age-related cataract surgery were enrolled in this study from March, 2011 to March, 2012. All patients underwent a general ophthalmic examination before operation, which included LogMAR UCVA, LogMAR BCVA, intraocular pressure, anterior segment slit lamp microscope examination, fundus, corneal thickness, ocular axial (A-scan AUTOSCANDB-3000C), corneal curvature measurements (Refractometer, KR8800, Topcon), hematological, and blood biochemical test.

Selection criteria: LogMAR BCVA>0.5, the preoperative results were that spherical equivalent was less than ±6D. Preexisting corneal astigmatism was from 0.75D to 2.50D. exclusion criteria: supervene with marginal degeneration, corneal scar, pterygium; diagnosed with fundus lesions or optic neuropathy of diabetic retinopathy, age-related macular degeneration (AMD), retinal vein/artery occlusion and so on before operation; exist lens subluxation and exfoliation syndrome in preoperative period; with surgery contraindications of ocular or general condition; has mental problems to respond that could not cooperative receive vision examination. All the patients selected agree to the tests and signed informed consent forms.

The patients were divided into 2 groups according to the extent of their corneal astigmatism: group A (0.75D–1.50 D) or group B (1.75D–2.50D). Everyone in each group received a random number from the random number table to establish the consulting order. The patients with even numbers received PCRIs, while those with odd numbers received Toric-IOL. Fifty-four cases (54 eyes) diagnosed with age-related cataract were chosen, including male (27 cases) and female (27 cases), and average age was 70.04±9.08 years (50 to 87 years). When both eyes of the same patient fulfilled the inclusion criteria, only 1 eye (the right eye) was included for analysis. The general information of these patients is shown in Table 1.

Table 1 General condition of patients

		Toric-IOL	PCRIs	*P*
Group A	Case	15	15	
	M/F	8/7	8/7	1.00
	Age (a)	67.33±10.26	70.47±8.03	0.36
	Astigmatism (D)	1.15±0.31	1.17±0.28	0.88
	Corneal thickness (μm)	550±13	553±15	0.66
	Oculi axis (mm)	23.03±0.67	23.23±0.86	0.50
Group B	Case	12	12	
	M/F	5/7	6/6	0.68
	Age (a)	72.17±9.55	70.75±8.61	0.71
	Astigmatism (D)	2.08±0.24	2.13±0.29	0.68
	Corneal thickness (μm)	560±14	552±15	0.22
	Oculi axis (mm)	23.27±0.87	23.59±0.5	0.28

Preoperative preparation

We made direction marks for corneal astigmatism in the steep axis, horizontal axis, and vertical axis before the operations. All procedures were performed with a slit-lamp microscope and angle-indicating dial. Based on the ocular axis and keratometry, we used the SRK/T formula to calculate the spherical refraction of IOL by employing SRK/II. Toric-IOL was counted with an online calculation program (http://www.acrysoftoriccalculator.com/). The data for keratometry, axial direction, diopter of IOL, surgery-induced astigmatism (0.5D) and the position of operative incision could be input online, for automatic determination of the type of IOL.

Surgical procedure

The procedures for peripheral corneal relaxing incisions (PCRIs)

A symmetrical incision was made using an ad-

justable-depth keratome, which was parallel to the corneal limbus. The incisions were as deep as 80–90% of the corneal thickness and were located in the peripheral cornea of the steep axis. Gills and Gayton's methods for designing surgical incisions and the operator's experience were used to establish the length and the position of the incisions from limbus in the light of astigmatism diopter: 1) 0.75D-1.50D, in the steep axis and within limbus 0.5 mm; incision length: 3.2 mm; 2) 1.75D-2.00D, in the steep axis and within limbus 1.0mm; incision length: 3.2 mm; 2.25D-2.50D, in the steep axis and within limbus 1.5 mm; incision length: 4.0 mm. The peripheral corneal incision on one side was made as a phacoemulsification incision. A continuous curvilinear capsulorhexis was then performed. The IOL was then implanted in the capsule. The corneal incisions were irrigated and the corneal epithelium was removed before ending the operation.

The procedures of toric-intraocular lens implantation

Continuous curvilinear capsulorhexis was performed through a transparent limbal tunnel incision, which was made, in accordance with preplanning, in temporal side or upper side. The same protocol a used for PCRIs was used to implant the IOL in the capsule. The astigmatism marker was rotated to the direction of corneal astigmatism in the steep axis. All these surgeries were performed by the same doctor.

Postoperative medications and follow up

Postoperative medications were compound tobramycin eye drops (Alcon) and 0.1% sodium hyaluronate eye drops. Each patient was scheduled to drop compound tobramycin eye drops for 5 weeks: 6 times per day for the first week, then 4 times per day in the following two weeks, 3 times per day in the next week, and once per day in the last week. The 0.1% sodium hyaluronate eye drops were used 4 times per day throughout the 4 week study. All results of LogMAR UCVA, LogMAR BCVA, subjective refraction, corneal curvature, and intraocular pressure were recorded.

Statistical analysis

The data were analyzed using SPSS software. Preoperative corneal astigmatism, which would be compared with postoperative corneal astigmatism of subjective refraction, was converted into Picture frame plane astigmatism based on an eye wire distance of 12 mm. The change in the astigmatism vector to the surgical eye was determined using the data, which were collected from pre and post surgery at each point in time, including degree and axis of astigmatism. The methods we used were established by the Z80111 work team of the American National Standard Institute (ANSI). Error vector (|EV|): the absolute size of astigmatism degree after operation. Surgically Induced Refraction Correction, |SIRC|: astigmatism changes because of operation. Correction Ratio, CR: If this was less than 1, the correction was insufficient. A value more than 1 meant too much correction. A value equaling 1 meant absolute correction.

Quantitative data were described as mean ± standard deviation (SD). The differences in the means between two groups were compared using a t-test. Frequency represented categorical data. χ^2 was used to analyze the ratio differences between each group. The differences in LogMAR UCVA, LogMAR BCVA, |EV|, |SIRC| and CR 6 months postoperatively were compared between the two groups using an independent sample test. A paired samples test was used to compare the differences in LogMAR UCVA, and |EV| at postoperative months 1 and 6. A value of $P<0.05$ was considered statistically significant.

Results

The effectiveness and safety of peripheral corneal relaxing incisions and a toric intraocular lens

All patients underwent successful operations without any intra or post operation complications. At 6 months postoperatively, all 54 eyes had a LogMAR BCVA≤0.2.

Patients who received PCRIs and Toric-IOL with LogMAR BCVA≤0.1 were not significantly different in group A (86.7% vs 93.3%, P=1.00) and in group B (75% vs 91.7%, P=0.59). In group A, no significant differences were seen for LogMAR UCVA (0.17±0.14 vs 0.13±0.10, P=0.70), |EV| (0.18±0.08 vs 0.17±0.10, P=0.13), |SIRC| (0.87±0.30 vs 0.92±0.38, P=0.71), and CR (0.75±0.16 vs 0.78±0.19, P=0.56) in patients who received PCRIs and Toric-IOL. However, in group B, significant differ-

ences were observed for LogMAR UCVA(0.32±0.14 vs 0.11±0.06, P<0.01), |EV|(1.17±0.36 vs 0.54±0.33, P<0.01)), |SIRC| (1.08±0.27 vs 1.68±0.32, P<0.01), and CR (0.51±0.13 vs 0.81±0.14, P<0.01). The LogMAR UCVA and |EV| between 1 and 6 months were not significantly different in patients in group A. However, the patients in group B showed significant differences. The LogMAR UCVA, |SIRC| and CR were greater for Toric-IOL than for PRCIs, while the |EV| was less for Toric-IOL than for PCRIs (Table 2).

Table 2 The effects of PCRIs and Toric-IOL 6 months postoperatively

		PCRIs	Toric-IOL	p
Group A	LogMAR UCVA	0.17±0.14	0.13±0.10	0.70
	LogMAR BCVA	0.03±0.08	0.02±0.08	0.80
	LogMAR BCVA(≤0.1)	13/15(86.7%)	14/15(93.3%)	1.00
	|EV|	0.48±0.22	0.37±0.19	0.13
	|SIRC|	0.87±0.30	0.92±0.38	0.71
	CR	0.75±0.16	0.78±0.19	0.56
Group B	LogMAR BCVA	0.08±0.08	0.04±0.07	0.52
	LogMAR BCVA(≤0.1)	9/12(75%)	11/12(91.7%)	0.59
	|EV|	1.17±0.36	0.54±0.33	<0.01
	|SIRC|	1.08±0.27	1.68±0.32	<0.01
	CR	0.51±0.13	0.81±0.14	<0.01

The stability of peripheral corneal relaxing incisions and the Toric intraocular lens in correcting astigmatism

In group A, the LogMAR UCVA and |EV| of the patients who received PCRIs were 0.13±0.14 vs 0.50±0.23(P<0.01) at 1 month postoperatively, 0.17±0.14vs 0.48±0.22 (P<0.01) at 6 month postoperatively, while for Toric-IOL, they were 0.13±0.13 vs 0.40±0.18 (P=0.08) at 1 month postoperatively and 0.09±0.07 vs 0.48±0.31 (P<0.01) at 6 month postoperatively. In the higher astigmatism group (group B), the |EV| was greater at 6 months postoperatively than at 1 month postoperatively, whereas UCVA decreased for both surgical methods. The changes were more obvious in the PCRI patients (Table 3).

Discussion

Modern phacoemulsification for cataract surgery has shifted from simple cataract surgeries to refractive surgery[8,11]. Postoperative astigmatism has already become an important element that can influence the effect of modern cataract refractive surgery. The refractive status can be more accurately controlled after the surgery. Most (60%) patients can be in a predesigned to address state, and the average error of diopter is only 0.40D. However, 30-40% patients with cataract are diagnosed with an astigmatism degree over 1D. The astigmatism degree can be controlled under 1D in only 43% of patients[12,13].

The astigmatism of cataract is mainly rooted in corneal astigmatism[14]. With increasing age, corneal astigmatism trends to irregular astigmatism[15]. PCRIs relax the cornea by symmetrical incisions made on peripheral cornea in the steep axis of refractive power. Under the influence of intraocular pressure and elastic stress, the corneal refractive power in the corresponding direction decreases as the vertical direction increases[16]. These features lead to a decrease in corneal astigmatism. When an incision is made deeper, longer, and closer to the corneal center, the refraction correction is greater. Nevertheless, unpredictability of the refraction correction can easily occur if too great an incision is made into the transparent cornea.

PCRIs can correct the corneal refractive degree ranging from 0.50D to 2.06D. The main difference is caused by preoperative astigmatism and the design of the surgical incision[17]. The parameters for the incision should be designed according to the preoperative degree of astigmatism, which is also an important factor that has a great influence on corrective effects of PCRIs. Based on the parameters used in past studies, our current study took preoperative

Table 3 The stability of PCRIs and Toric-IOL after 1 and 6 months

		PCRIs(n=15)		P	Toric-IOL(n=15)		P
		1 month	6 months		1 month	6 months	
Group A	LogMAR UCVA	0.13±0.14	0.17±0.14	0.74	0.13±0.13	0.13±0.10	0.97
	|EV|	0.50±0.23	0.48±0.22	0.58	0.40±0.18	0.37±0.19	0.55
Group B	LogMAR UCVA	0.21±0.12	0.31±0.13	0.39	0.09±0.07	0.11±0.06	0.76
	|EV|	0.81±0.34	1.17±0.36	<0.01	0.48±0.31	0.54±0.33	<0.01

astigmatism into account and combined this knowledge with our own surgical experience to correct the preoperative astigmatism. Our results showed that the use of PCRIs gave an average correction of 0.87D in the lower astigmatism group (0.75D-1.50D) and 1.08D in the higher astigmatism group (1.75D-2.50D). Differences in the LogMAR UCVA and |EV| between 1 and 6 months were not significant in patients in the lower astigmatism group perhaps because the incision was designed in the limbal region, or was too small, or had no obvious influence on corneal shape during recovery. The higher astigmatism patients showed an obvious regression where |EV| increased from 0.81D to 1.17D between 1 and 6 months postoperatively. The main reason for this regression was that the incision was located in the inner 1-1.5mm of the limbal region, and the incision was larger so that it had a greater influence on corneal shape during recovery[18].

The Toric-IOL has been introduced recently for management of astigmatism. The Toric-IOL is designed to replace the cataractous lens of an eye and to correct corneal astigmatism. Thus, if Toric-IOLs are safe and efficient, an increase in quality of life should be observed in cataract patients with astigmatism. This increase in quality of life would not have been as significant had only cataract or astigmatism alone been treated in this patient population. The Toric-IOL achieves the goal of correcting preexisting astigmatism through neutralizing corneal astigmatism[19]. Toric-IOL implant patients do not suffer from the disadvantages associated with corneal refractive surgery, and ametropia combined with astigmatism can be successfully corrected. The main domestic types of AcrySof Toric IOLs are SN60T3, SN60T4, and SN60T5. The diopters of the cylinder are 1.50D, 2.25D, and 3.00D with scopes for correcting corneal astigmatism from 1.03D, to 1.55D, to 2.06D, respectively. The corresponding subjective refraction degrees are 1.02D, 1.52D, and 2.01D, respectively. The degree to which the Toric-IOL corrects can be estimated[20], but the minimum between each type of diopter of the cylinder is 0.75D. The stability of the axis of the lens after implantation is also a primary factor that influences the correcting effect. The correction effect decreases by 3.3% with every 1o of lens rotation. The AcrySof Toric IOL is intraocular, which is hydrophobic and takes advantage of a modified loop. The AcrySof Toric IOL has superior biological compatibility and rotary stability in the capsular bag so that the angle of rotation is less than 4o after one year of implantation[21,22].

In our study, at 6 months postoperatively, the average |EV| was 0.37D in the lower astigmatism patients and 0.54D in the higher astigmatism patients. In the lower astigmatism patients, |EV|, which was respectively 0.40D and 0.37D at 1 and 6 months postoperatively, doesn't show obvious regress. In higher astigmatic patients, |EV| increased from 0.48 to 0.54 from 1 to 6 months postoperatively, indicating an obvious regression. Our results indicate that both the Toric-IOL implantation and PCRIs were safe and effective for astigmatism correction in patients with cataract. They can be used with equal effect in lower astigmatism patients. In higher astigmatism patients, the effectiveness of Toric-IOL is superior to that of PCRIs. Some regression occurred at 6 months postoperatively when astigmatism of more than 1.75D was corrected, regardless of the use of Toric-IOL or PCRIs. Therefore, follow-up should be scheduled over 6 months when we evaluate the effects of these procedures. The effectiveness of PCRIs, which is related to surgical design, the eyeball parameters before surgery, and postoperative treatments, indicates that further study is needed on larger samples to analyze how all these factors contribute to the final surgical effect.

What was known

1)Modern phacoemulsification for cataract surgery has shifted from simple cataract surgeries to refractive surgery.

2)Postoperative astigmatism has already become an important element that can influence the effect of modern cataract refractive surgery.

3)The astigmatism of cataract is mainly rooted in corneal astigmatism.

What this paper adds

1)Toric-IOL implantation and PCRIs were both safe and effective for astigmatism correction in patients undergoing cataract surgery.

2)Toric-IOL implantation achieved an enhanced effect over PCRIs in higher astigmatism patients.

3)PCRIs showed more refractive regression than Toric-IOL 6 months postoperatively.

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