

Corneal astigmatism correction with scleral flaps in trans-scleral suture-fixed posterior chamber lens implantation: a preliminary clinical observation

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Abstract

• **AIM:** To study the impact of scleral flap position, under which the posterior chamber intraocular lenses (PC-IOL) were sulcus-fixed by trans-scleral suture, on cornea astigmatism.

• **METHODS:** Twenty-six aphakic or cataract eyes were comprised in this prospective noncomparative case series study. Eleven eyes had traumatic cataract removed without sufficient capsular support, 3 had blunt trauma with subluxated traumatic cataract, 8 had undergone vitreoretinal surgery and 4 had congenital cataract removed. The average age was 54 years (range 21-74 years), with 17 men and 7 women. The foldable PC-IOL was fixed in sulcus by trans-scleral suture. The incision for IOL implantation was made 1mm posterior to limbus along the steepest meridian of cornea, while scleral flaps to bury the knots of trans-scleral suture were made along the flattest meridian. All the surgeries were performed by a single doctor (Ma L), and the follow up was at least 13 months (range 13-28 months). The preoperative, 3 months and 1 year postoperative corneal curvature along the steepest and flattest cornea meridian and overall cornea astigmatism were compared.

• **RESULTS:** The curvature along the steepest meridian changed from $44.25 \pm 2.22D$ preoperatively to $44.08 \pm 2.16D$ at 3 months postoperatively, and $43.65 \pm 5.23D$ at 1 year postoperatively ($P > 0.05$); the curvature along the flattest meridian changed from $41.24 \pm 2.21D$ preoperatively to

$43.15 \pm 3.94D$ at 3 months postoperatively, and $42.85 \pm 5.17D$ at 1 year postoperatively ($P < 0.05$); and the surgery induced astigmatism (SIA) on cornea was calculated by vector analysis, which was $2.42 \pm 2.13D$ at 3 months postoperatively, and $2.18 \pm 3.42D$ at 1 year postoperatively, the difference was statistically significant ($P < 0.05$).

• **CONCLUSION:** The scleral flap made along the flattest meridian, under which the posterior chamber intraocular lenses (PCIOL) were sulcus-fixed by trans-scleral suture, can steepen the cornea in varying degrees, thus reducing preexisting corneal astigmatism.

• **KEYWORDS:** intraocular lens; suture fixation; astigmatism; lack of posterior capsule

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INTRODUCTION

With recent development of smaller incision, more accurate biometry for intraocular lens (IOL) calculation and correction of preexisting corneal astigmatism, cataract extraction with IOL implantation not only achieve better vision rehabilitation nowadays, but also is known as refractive cataract surgery, aiming for better postoperative vision quality^[1,2]. Aphakic eyes without sufficient posterior capsular or zonular support for posterior chamber intraocular lens (PCIOL) are not rare in the clinical practice. Usually there is more severe corneal astigmatism in affected patients than normal cataract patients because of previous trauma or surgical history in these aphakic eyes. When secondary IOL implantation is necessary in such cases, the correction of preexisting corneal astigmatism should also be taken into consideration.

Although there are many alternatives for the secondary IOL implantation in the aphakic eyes with insufficient capsular or zonular support which include angle-supported anterior chamber intraocular lens (ACIOL), iris-fixated ACIOL,

iris-sutured or iris-fixated posterior chamber (PCIOL) [3-5], trans-sclera sutured PCIOL is still a better choice, especially in young patients [6,7], because of the possible complications related to progressive corneal endothelium damage, iris pigment dispersion and even secondary glaucoma [1,8,9].

In cataract surgery, the effects of incision during cataract removal and IOL implantation on corneal astigmatism are well documented [10-13]. It is common practice for cataract surgeons to design the incision according to preexisting corneal astigmatism. While the impact of scleral flap on corneal curvature is not quite yet understood, this study was designed to investigate the effects of the scleral flaps position on corneal astigmatism in cases of sclera fixated PCIOL surgery.

MATERIALS AND METHODS

Subjects This prospective noncomparative case series study comprised of 26 eyes of 24 patients who were treated in the Department of Ophthalmology, the 4th Affiliated Hospital of China Medical University between Nov. 2006 and Dec. 2007. The tenets of the Declaration of Helsinki were followed, and full ethical approval was obtained from the 4th Affiliated Hospital of China Medical University. Informed consent was obtained from all patients after a full explanation of procedures and possible consequences of the study and surgery. In these patients, 11 patients (11 eyes) previously had traumatic cataract removal without sufficient capsular support (3 months-16 years postoperatively), 3 patients (3 eyes) had blunt trauma with lens subluxation, 8 patients (8 eyes) had undergone vitreoretinal surgery (3 months-2 years postoperatively) in which 5 had diabetic retinopathy, 2 were of traction retina detachment, 1 was eyeball perforation trauma, and 2 patients (4 eyes) had congenital cataract removal corrected with spectacles. There were 17 men and 7 women. All patients had a complete ophthalmologic examination including uncorrected vision acuity (UCVA) on Log Mar chart, best corrected vision acuity (BCVA) on Log Mar chart, slitlamp evaluation of the anterior segment, Goldmann applanation tonometry, detailed fundus assessment after pharmacologic pupil dilation, cornea endothelial cell count, cornea curvature on the steepest and flattest meridian by manual keratometer (YZ38,66 Vision Tech.), cornea topography (KR8100P, Topcon, Japan), and B-mode ultrasound assessment. Biometry was done with IOL Master (Carl Zeiss Meditec, Germany). The SRK II formula was used to calculate the IOL power. The intended postoperative refraction was -0.50 diopter (D).

The exclusion criteria included intraocular pressure greater than 30mmHg, cornea endothelial cell counting less than 1000/mm², refraction correcting with no improvement in acuity. All surgeries were performed by the same experienced cataract doctor (Ma L).

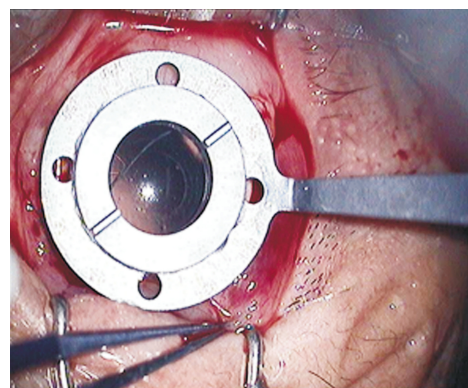


Figure 1 Cionni Toric Axis Marker in use during surgery

Surgical technique 1) Before surgery, the horizontal and vertical meridians were marked at limbus in sitting position under slit lamp; 2) the artificial lens was a 1-piece hydrophilic acrylic foldable IOL (Superflex[®], Rayner); 3) during surgery, the Cionni Toric Axis Marker (Duckworth & Kent Ltd.) was used to determine the steep and flat meridian (Figure 1). We labeled the line on the top portion of the mark to the desired meridian for the incisions. The Axis Marker was then positioned over the eye, lining up the holes at the horizontal and vertical meridians with the previously made limbal reference marks, the blades on the underside would make the desired marks on the limbus; 4) 50% thickness limbal-based triangular scleral flaps were made, symmetrically centered at the mark of the flattest cornea meridian. The base of the triangle was 3mm long; 5) the scleral tunnel incision for dislocated lens removal and/or IOL implantation was made with a 3.0mm sharp blade 1mm posterior to limbus, centered at the mark of the steepest cornea meridian. For secondary IOL implantation, this incision was made after the trans-scleral suture was set through the ciliary sulcus; 6) the dislocated lens was removed by phacoemulsification in the 3 cases with blunt trauma; 7) a straight, 16mm-long needle carrying Ethicon 10-0 polypropylene suture was introduced into the eye 1mm posterior to limbus under 1 scleral flap exactly at the position of the mark of the steepest cornea meridian, and passed under the other flap with a bent 27-gauge tuberculin needle as described by Lewis, which was inserted 1mm posterior to limbus exactly at the position of the mark of the other end of the steepest cornea meridian; 8) the 10-0 polypropylene was externalized through the incision for IOL implantation with a hook or forceps and cut and tied to the end of each of the loop hepatics of the Rayner lens before and after the lens was injected into the eye. The lens was loaded into the injector and held by assistant. With mild pushing, the end of the front hepatic exposed from the cartridge. We put the suture through the hole of the hepatic and tied at the end of the loop, made sure the knot tighter to

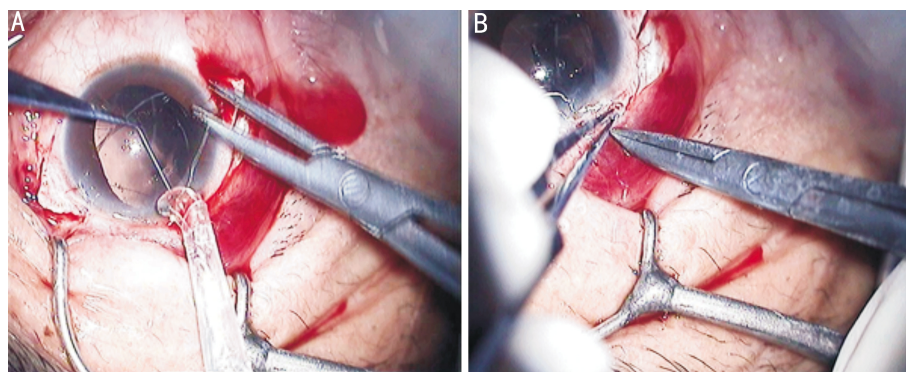


Figure 2 Surgery technique A: The technique of putting suture through the hole of one of the haptics of PCIOL; B: The technique of applying suture through the hole of other haptic of the lens

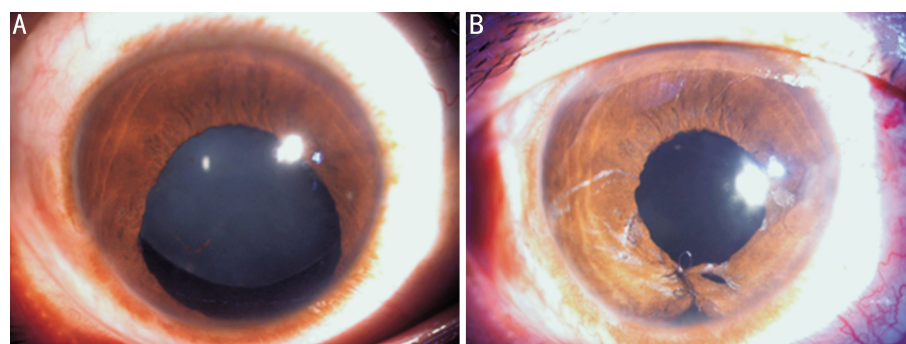


Figure 3 The pupil A: Large pupil and subluxated lens due to blunt trauma; B: The reconstruction of the pupil with suture to cover the optic of the sclera fixated PCIOL

prevent slipping and loosening (Figure 2A). If we stopped pushing and draw the plunger backwards, the hepatic would slide back into the cartridge. Then the lens could be implanted into the anterior chamber through the 3mm scleral tunnel incision. We pulled the end of the posterior hepatic out of the incision with forceps, put the suture through the hole of the hepatic and tied at the end of the loop. Then with the two hepatics tied by suture, the lens could be manipulated into sulcus (Figure 2B); 9) the IOL was introduced into the eye, the hepatics rested in ciliary sulcus, the lens was centered by pulling up the external ends of the suture; 10) the externalized sutures were tied on the scleral bed and the knots were buried by scleral flaps, which were sewn shut with 10-0 nylon; 11) in the cases where vitreous was present in the anterior chamber and pupil region, or residual cortex and fibrotic membrane, anterior vitrectomy was performed through the tunnel incision for IOL implantation; 12) in the cases where the pupil was larger than the optic IOL, round or irregular (in cases of blunt trauma, Figure 3A), the pupil was reconstructed by the polypropylene suture ^[14] (Figure 3B). Postoperative evaluations were performed at 1 month, 3 months, and 1 year and included UCVA, BCVA, keratometry, topography, slitlamp evaluations, Goldmann applanation tonometry, and fundus evaluation.

Statistical Analysis Data analysis was performed using

Table 1 Preoperative demographic characteristics of patients
Mean ± SD

Characteristic	Value
Eyes (n)	26
Age (yr)	54.5 ± 15.02
Range	21 to 74
Sex (M/F)	17/7
Keratometry (D)	K _{Max} 44.25 ± 2.22
	K _{Min} 41.24 ± 2.21
Range	38 to 49
IOL power (D)	18.30 ± 14.27
Range	3 to 25.5
Axial Length (mm)	24.359 ± 5.18
Range	20.82 to 29.72

IOL: intraocular lens; K_{Max}: cornea curvature on steep axis; K_{Min}: cornea curvature on flat axis

SPSS for Windows (version 13.0, SPSS, Inc.). Normality was checked by the Shapiro-Wilk test, and the paired-*t* test was performed to compare the outcomes. Differences were considered to be statistically significant when the *P* value was <0.05. Curvature change was calculated as the difference between the mean preoperative and postoperative manual keratometer readings. The SIA was calculated by the Holladay-Cravy-Koch (HCK) method^[15,16].

RESULTS

The mean age of the 17 men and 7 women was 54.5 ± 15.02 years (SD), (range 21 to 74 years). The mean follow-up time frame was 22 ± 8 months (SD), (range 12 to 28 months). The patients' demographics were shown in Table 1.

Table 2 SIA in cornea keratometric and topographic readings (Mean±SD, D)

	Preop. value	Postop. value		SIA at 1-year postop
		3-month	1-year	
K _{max} ¹	44.25±2.22	44.08±2.16	43.65±5.23	
K _{min} ¹	41.24±2.21	43.15±3.94	42.85±5.17	
Overall cornea astigmatism ²	3.01±1.16	1.85±2.3	1.56±1.19	2.18±3.42

¹K_{max} and K_{min} were measured by manual keratometer; ²Overall cornea astigmatism were get from topographic readings

Preoperative and postoperative UCVA and BCVA The mean preoperative UCVA was 1.7±0.42 (counting fingers to 0.7) (LogMar), the preoperative BCVA was 0.6±0.21(0.9 to 0.1), while the postoperative UCVA and BCVA at the last follow-up were 0.7 ±0.26, 0.57 ±0.27 respectively. The differences were statistically significant ($P<0.05$) in the UCVA but not statistically significant ($P>0.05$) in the BCVA.

Preoperative and postoperative cornea curvature and astigmatism The curvature along the steepest meridian changed from 44.25±2.22D preoperatively to 43.65±5.23D postoperatively ($P>0.05$). The curvature along the flattest meridian changed from 41.24 ±2.21D preoperatively to 42.85±5.17D postoperatively ($P<0.05$). The mean corneal astigmatism was 3.01±1.16D (0.89 to 6.37) preoperatively and 1.56 ±1.19D (0.04 to 4.19) postoperatively, the difference was statistically significant ($P<0.05$). The surgery induced astigmatism (SIA) on the cornea was calculated by vector analysis, which was 2.42 ±2.13D at 3 months postoperatively, and 2.18 ±3.42D at 1 year postoperatively (Table 2); the difference was statistically significant($P<0.05$).

Complications Hypotony developed in the eyes of 2 subjects and recovered spontaneously in 1 month. Intraocular pressure was elevated in 3 eyes, which was alleviated through medication. Minor hyphema (less than 2mm high in anterior chamber) was found in 2 eyes, absorbed in few days without management. Cystoid macular edema (CME) occurred in 1 eye 40 days postoperatively and was successfully corrected with sub-tenon's 20mg triamcinolone injections once a week, for 4 weeks. No cases of IOL tilt, IOL decentration, or choroidal and retinal detachments were observed during the follow-up.

DISCUSSION

After implantation of IOL, in eyes with insufficient posterior capsular or zonular support, when postoperative UCVA is close to or better than preoperative BCV, it can be considered as the best visual outcome. To get this result, in addition to accurate biometry for IOL, the other measures taken include correction preexisting corneal astigmatism by varied incision types ^[2], and paired opposite clear cornea incisions ^[17,18], accurate keratotomy ^[19], and limbal relaxing

incisions ^[20]. However, in the widely accepted trans-scleral PC-IOL fixation surgery, there are two scleral flaps besides the IOL implantation incision, which may also affect corneal curvature. Scleral flaps were originally located at 3 and 9 o'clock positions. The postoperative corneal astigmatism increased in some cases resulting in poor postoperative UCVA. Furthermore, in this noncomparative clinical trail, we made the scleral flaps along the flat meridian, while the incision for IOL implantation was made along the steep meridian.

SIA caused by cataract incisions was well described. In general, the incision parallel to limbus can flatten corneal curvature. The SIA increases as the incision getting closer to corneal center. In our study, the scleral tunnel incision for suture-fixed IOL implantation was made along the steep meridian, 1mm posterior to limbus and 3mm in width, which was relatively far from the corneal center. The change in corneal curvature along this meridian was 44.25 ±2.22D preoperatively to 43.65 ±5.23D at 1 year postoperatively, indicating the decrease in astigmatism, but was not statistically significant.

However, SIA caused by scleral flaps was not quite understood. Koch *et al*^[21] reported that there was a tendency towards having mean corneal flattening with resections and mean corneal steepening with recessions of the scleral flap. In our study, the curvature along the flat meridian, on which the scleral flaps were made, was statistically and significantly increased, 41.24 ±2.21D preoperatively to 42.85±5.17D at 1 year postoperatively. This change maybe caused by scleral flaps and the trans-sulcus suture.

In many published clinical trails, the overall SIA was recorded ^[10-13], in which there was only one incision site was present. While there were two incision sites of scleral flaps in this study, which have opposite effects on corneal astigmatism, the focus was on the change in corneal curvature along the initial incisions. The overall SIA estimated as the difference between mean preoperative and postoperative topographic readings, which was 2.18±3.42D. Because of the correction of aphakic spherical error and corneal astigmatism, some patients got better postoperative UCVA.

The SIA is related to the fibrillar structure of the cornea and sclera [22]. Corneal stroma is made of -200 lamellae, each roughly parallel to the surface of the eye but of random orientation. Peripherally, the corneal fibril bands run circumferentially and merge with scleral fibril to form a circumcorneal annulus located 1mm into the sclera. Beyond that, scleral collagen fibril still run in a circular pattern, parallel to the limbus, although arranged in less ordered lamellae [23,24]. When the incision for IOL implantation is made on the sclera, like in this study, the orientation is tangential to corneal circumference and will penetrate the circumcorneal annulus parallel to the majority of the fibrils, causing less damage than an incision which will cut perpendicularly through corneal fibrils. However, the scleral flaps were triangular in shape, and its sides cut perpendicularly through the circumcorneal annulus. This setup reduces the tensile strength to the corneal fibrils along its meridian, resulting in bulges of corneal fibrils as a result of their own elasticity. This may explain the findings of our study that the scleral flaps along the flat meridian can steepen the corneal curvature. With the combined effect of scleral tunnel incision on steep axis and scleral flaps on flat axis, the overall SIA in our study was $2.18 \pm 3.42D$, indicating that both the incision for IOL implantation and scleral flap may correct the preexisting corneal astigmatism in trans-scleral suture-fixed PC-IOL implantation. This also offers another support to the necessity of making scleral flaps, although some surgeons believe performing trans-scleral surgery without flaps is better for integrity of the sclera [25].

The lens we used for suture-fixation was a one piece hydrophilic acrylic foldable IOL, 6.25mm \pm 12.50mm. The lens can be injected through a 3-mm incision, (small-incision) thus avoiding complications of wide-incision surgery such as IOP fluctuation, recurrent bleeding, choroidal detachment, exogenous infection [26,27]. There is a hole in the Rayner lens hepatic. It is easy for the 10-0 polypropylene suture to be tied to exact symmetric plane of the hepatic loops without measurement, and with a tighter knot, the lens hepatic may transform very little, so knots are less slippery. Another reason for choosing this lens is the size of its optics, 6.25mm. In the patients needing suture-fixed IOL implantation, there are usually papillary sphincter problems resulting from previous surgery or trauma. An IOL with larger optics may compensate for vision disturbance from big or irregular pupils. In 2 patients with atonic pupil who cannot cover the lens optic, we reconstructed the pupil with polypropylene suture. Although

there was mild bleeding from iris sutures (both cases), it was absorbed in few days without further complications. The patients were satisfied with results.

In conclusion, the scleral flaps which cover the suture knots have limited impact on corneal astigmatism. However, its effect is related to the thickness, construction and the position of the flap, including the tightness of the suture knot. Long-term outcomes and a larger sample are necessary for the evaluation of the scleral flaps effect on the overall corneal astigmatism.

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