นิพนธ์ต้นฉบับ/Original Article

การเลือกตำแหน่งแผลผ่าตัดต้อกระจกที่เหมาะสม ช่วยแก้ไขภาวะสายตาเอียงได้

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บทคัดย่อ

วัตถุประสงค์: เพื่อศึกษาผลของการเลือกลงตำแหน่งแผลผ่าตัดต้อกระจกเพื่อแก้ไขภาวะสายตาเอียง

วิธีวิจัย: ผู้ป่วยที่เข้ารับการผ่าตัดต้อกระจกที่ศูนย์การแพทย์กาญจนาภิเษกตั้งแต่ปี 2553-2558 เลือกลงแผลที่ steepest meridian แบ่งผู้ป่วยออกเป็น 2 กลุ่ม กลุ่มที่ 1 ผู้ป่วยที่มีภาวะสายตาเอียงก่อนผ่าตัดน้อยกว่า 1.50D กลุ่มที่ 2 ผู้ป่วยที่มีภาวะตั้งแต่ 1.50D ขึ้นไป คำนวณข้อมูลของค่าสายตาเอียงและแกนของสายตาเอียง (vector analysis) (K1/K2) ก่อนผ่าตัด, ระยะเวลา 1 เดือนและ 3 เดือนหลังผ่าตัดแล้วเปรียบเทียบกัน

ผลการวิจัย: ผ่าตัดตาผู้ป่วยที่เข้าเกณฑ์การวิจัยทั้งหมด 70 ข้าง เปรียบเทียบค่า median astigmatism ก่อนผ่าตัด (1.50D) พบว่าที่ระยะเวลา 1 เดือนหลังผ่าตัดลดลงเป็น 1.25D (p<0.001) และที่ 3 เดือนหลังผ่าตัดลดลงเป็น 1.00D (p<0.001)

เปรียบเทียบค่าสายตาเอียงก่อนและหลังผ่าตัด ระหว่างกลุ่ม 1และกลุ่ม 2 พบว่าค่าสายตาเอียง ก่อนผ่าตัด 2.00D ในกลุ่มที่มีสายตาเอียงตั้งแต่ 1.50D ขึ้นไป (กลุ่ม 2) มีการเปลี่ยนแปลงของค่าสายตาเอียง โดยที่ระยะเวลา 1 เดือน ค่าสายตาเอียงเท่ากับ 1.50D ที่ระยะเวลา 3 เดือนค่าสายตาเอียงเท่ากับ 1.00D ค่าสายตาเอียงก่อนและหลังผ่าตัดที่ 1 เดือน และ 3 เดือนมีความแตกต่างอย่างมีนัยสำคัญทางสถิติ (p<0.001) ในกลุ่มที่มีสายตาเอียงน้อยกว่า 1.50D (กลุ่ม 1) พบว่าไม่มีความแตกต่าง ค่าสายตาเอียง ก่อนผ่าตัดเท่ากับ 0.75D หลังผ่าตัด 1 เดือนเท่ากับ 0.75D (p=0.97) หลังผ่าตัด 3 เดือนเท่ากับ 0.75D (p=0.83)

เมื่อพิจารณาจาก vector analysis พบว่าค่าความโค้งของกระจกตา ไม่มีการเปลี่ยนแปลงทั้ง vertical component และ horizontal component เมื่อพิจารณาจากการคำนวณค่า surgically induced astigmatism (SIA) ของผู้ป่วยทั้งหมดพบว่าที่ 1 เดือนหลังผ่าตัดเปลี่ยนแปลง 0.60D, ที่ 3 เดือนหลังผ่าตัดเปลี่ยนแปลง 0.70D

สรุป: การเลือกลงแผลผ่าตัดที่ตำแหน่ง steepest meridian ช่วยลดภาวะสายตาเอียงก่อนผ่าตัดในกลุ่มที่มีสายตาเอียงตั้งแต่ 1.50D เป็นทางเลือกให้จักษุแพทย์นำไปใช้กับผู้ป่วยที่มีสายตาเอียงตั้งแต่ 1.50D ที่ไม่สะดวกใช้ เลนส์แก้วตาเทียมชนิดแก้สายตาเอียง (toric IOL) **จักษุเวชสาร 2016; กรกฎาคม-ธันวาคม 30(2): 85-94.**

คำสำคัญ: การลงแผลกระจกตา การแก้สายตาเอียง ต้อกระจก

ผู้นิพนธ์ทั้งหมดไม่มีส่วนเกี่ยวข้องหรือผลประโยชน์ใดๆ กับผลิตภัณฑ์ที่ได้กล่าวอ้างถึงในงานวิจัยนี้

ศูนย์การแพทย์กาญจนาภิเษก มหาวิทยาลัยมหิดล

นิพนธ์ต้นฉบับ/Original Article

Optimal Corneal Incisions to Correct Pre-existing Astigmatism in Cataract Surgery

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Abstract

Objective: To explore the effect of clear corneal incisions on reducing astigmatism in different degrees of pre-existing astigmatism

Materials & Methods: We retrospectively reviewed patients who underwent phacoemulsification at Golden Jubilee Medical Center between 2010 and 2015. A sutureless clear corneal incision was made on the steepest axis. Patients were divided into 2 groups by degree of preoperative astigmatism (<1.50 and ≥1.50 D). The differences of postoperative astigmatism and vector analysis (K1/K2) at one month and three months postoperatively were compared.

Results: Overall in 70 cataract operations, median astigmatism reduced from 1.50 D preoperatively to 1.25 D at one month postoperatively (p<0.001), and 1.00 D at three months postoperatively (p<0.001). The difference between preoperative (2.00 D) and 1-month and 3-month postoperative astigmatism (1.50 D and 1.50 D) was statistically significant only in the severe group (≥1.50 D) (p<0.001). No significant difference (0.75 D vs. 0.75 D and 0.75 D) was found in the mild group (<1.50 D), neither at one month (p=0.97) nor three months after surgery (p=0.83). Vector analysis showed no significant change in either vertical or horizontal components of astigmatism. The overall surgically induced astigmatism in this study was 0.60 D at one month, and 0.71 D at three months postoperatively.

Conclusion: A clear corneal incision on the steepest axis in phacoemulsification cataract surgery can help reduce pre-existing astigmatism only in severe astigmatism over 1.50 D, and this may be beneficial in patients with astigmatism over 1.50 D who undergo a cataract surgery. **Thai J Ophthalmol 2016; July-December 30(2): 85-94.**

Keywords: Corneal incision, Astigmatism Correction, Cataract

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Introduction

Cataract is one of the most common causes of blindness and is conventionally treated with surgery. Visual loss occurs because the opacification of the lens obstructs the light from passing and being focused on to the retina. This opacification process is mostly due to biological aging.

Nowadays, phacoemulsification is the most widely used cataract surgery. This procedure uses ultrasonic energy to emulsify the cataract lens. Entry to the eye is done through a small self-sealing incision, which has a diameter of 2.8 to 3.2 mm and most likely will not need stitches. Its advantages are shorter operative time and rapid visual rehabilitation. Precise intraocular lens (IOL) power calculation is essential for optimal benefits of implant surgery. A simple monofocal IOL, designed with a single focal point to correct cataracts and provide distant vision, enhances visual quality for patients with simple myopia or hyperopia. However, spectacles should be considered to correct residual astigmatism after cataract surgery. A toric lens, on the other hand, has a single focal point, and is designed to correct both cataracts and pre-existing astigmatism. This lens not only helps with distant vision, but also offers enhanced image quality, without the need for glasses after surgery. A toric lens has two different powers with curves at different angles. One curve is for astigmatism and the other is for myopia or hyperopia. However, toric lenses are expensive and not readily available in all hospitals in developing countries such as Thailand. Moreover, improper alignment or rotation of the IOL after surgery may result in more residual astigmatism than predicted. For every 1 degree the toric IOL axis is away from the true post-operative axis of astigmatism, there will be a 3.3% loss of toric correction[1]. Thus, the toric lens is still not a popular choice for cataract surgery in mild astigmatism.

Theoretically, small amounts of astigmatism can be managed by placing the surgical wound to coincide with the steep axis of astigmatism. Nevertheless, it may be difficult to operate along some axes, particularly if a patient is relatively enophthalmic or has a large brow or nose bridge. Surgeons frequently choose a temporal corneal incision because it provides better exposure to the surgical limbus, even in deep-set eyes. Several studies recommend that choosing the location of a corneal incision based on preexisting astigmatism offers potential benefit[2,3]. A clear corneal incision causes flattening in the incised meridian (increasing the radius of curvature) and steepening in the meridian 90 degrees away[2,4].

The effect of corneal incision to induce post-operative astigmatic change between patients with different severity of astigmatism has never been concluded. In this study, we explored the effect of corneal astigmatic change after putting corneal incisions at the steep axis of astigmatism in patients with preexisting astigmatism less than 1.5 diopter (D) and those with astigmatism of 1.5 D or more.

Materials & Methods

Patients with visually significant cataract who had cataract surgery at Golden Jubilee Medical Center, Mahidol University, Thailand between July 2010 and June 2015 were included in this retrospective cohort study. The study was approved by Mahidol University Institutional Review Board. The patients were given written informed consent of the plan, consequences and risks of treatment.

We included patients who underwent phacoemulsification with foldable IOL insertion in capsular bag and had a sutureless clear corneal incision. Patients who had underlying causes of autoimmune diseases, connective tissue disorders and poor controlled diabetes mellitus which tend to impair wound healing were excluded from this study. Patients who had a past history of intraocular surgery, radial keratectomy, excimer laser to reshape cornea or traumatic corneal laceration repair were excluded. We also excluded patients with progressive increase in corneal curvature, for example, keratoconus and pellucid marginal degeneration, and those whose curvature of cornea could not be measured. Patients found to have phacodonesis or unstable capsule with missing zonules and patients who had other simultaneous ocular operation with cataract extraction procedure, such as pterygium excision, were also excluded from the study population.

Preoperatively collected data included age, gender, side, type of cataract, uncorrected visual acuity (UCVA), best corrected visual acuity (BCVA) by Snellen chart, corneal astigmatism covariates obtained from Canon RK-F1 Autorefractor/Keratometer (Canon, Tokyo, Japan) [refractive power, vertical component of a vector (K1), horizontal component of a vector (K2) and their axes], immersion A-scan, IOL power (calculated by SRK-T formula[5], aiming for a postoperative refraction of -0.50 D), and fundoscopic examination.

All operations were performed by the same surgeon who is right-handed. Retrobulbar block and a two-step, self-sealing clear corneal incision (3.0-mm blade) were applied in all cases. The location of corneal incision was based on pre-existing astigmatism, at the steepest axis. For an eye without astigmatism (cylindrical power = 0 D), a corneal incision was made at temporal site. After introduction of viscoelastic material into the anterior chamber, a 5-mm capsulorhexis was made, followed by hydrodissection. The phacoemulsifier machine, INFINITI® Vision System (Alcon, TX, USA) with the Ozil® torsional handpiece (Alcon, TX, USA), was applied to divide and concur or phaco chop and aspirate cortical masses. Acrysof® SN60WF IOL implant (Alcon, TX, USA) was inserted. The corneal incision was left unsutured. Postoperatively, patients were given 1% prednisolone acetate eye drops every hour, levofloxacin eye drop *qid*, maxitrol ointment once a day, and the regimen was tapered over one months. Patients were examined at one day, one week, one month and three months postoperatively.

Postoperative data were collected at one month and three months after surgery, including UCVA, BCVA, corneal astigmatism covariates obtained from Autorefractor/Keratometer (refractive power, K1/K2 and their axes), date of surgery, location of corneal incision, and surgically induced astigmatism (SIA).

The corneal SIA was calculated by means of vector analysis using the Holladay 10-step formula on the basis of the results of topography. The Microsoft Excel-based SIA Calculator software has been obtained from https://sia-calculator.com[6]. This program has been designed to calculate the amount of SIA created during the cataract surgical procedure. Information about date of surgery, age, eye laterality, location and site of corneal incision, preoperative and postoperative K1, K2 and their axes were input into the calculator program, and SIA magnitude and axis were calculated.

The preoperative and postoperative astigmatism, K1, K2 and their axes were described in terms of their median and inter-quartile range (IQR), and compared using Wilcoxon sign-rank test. Patients were then separated into two groups by severity of preoperative astigmatism with the cut-off point at the median astigmatism of the study cohort. Patients with cylindrical power of less than 1.50 D were assigned into mild astigmatism group (Group 1), while patients with cylindrical power of 1.50 D or more were in severe astigmatism group (Group 2). The difference of variables between both groups was compared using Mann-Whitney test. The level of significance at 0.05 was used. There was no missing value of any variables included in the analyses. All statistical analyses were performed using Stata® version 11 (StataCorp, College Station, TX, USA).

Results

There were 70 cataract operations (32 on right eyes and 38 on left eyes) in 50 patients included in this study. Patients were divided into two groups: Group 1 (mild astigmatism group) consisted of 30 eyes with cylindrical power of less than 1.50 D (right eye, n=12; left eye, n=18); and Group 2 (severe astigmatism group) contained 40 eyes with cylindrical power of 1.50 D or more (right eye, n=20; left eye, n=20). The median and IQR of preoperative astigmatism were 1.50 D (0.75 D to 2.25 D). At one month and three months postoperatively, the median (IQR) decreased to 1.25 D (0.75 D to 1.50 D) and 1.00 D (0.75 D to 1.50 D), respectively (Figure 1). There was a statistically significant difference between preoperative and postoperative astigmatism at both one month ($p<0.001$) and three months ($p<0.001$).

Vector analyses of astigmatism showed that there was no statistically significant difference in the vertical component of astigmatism at one month postoperative ($p=0.09$) and three months postoperative ($p=0.74$). The median preoperative K1 was 44.87, and postoperative K1 at one month and three months were both 44.88 (Figure 2). There was also no significant difference between preoperative and postoperative horizontal component of astigmatism at one month ($p=0.39$) and three months ($p=0.12$). The median preoperative K2 was 43.75, and postoperative K2 at one month and three months were both 43.94 (Figure 3).

The median and IQR of the magnitude of SIA at one month and three months postoperatively were 0.60 D (0.38 D to 1.00 D) and 0.71 D (0.42 D to 1.10 D), respectively. The change in the axis of astigmatism at one month postoperatively was 99 degrees (83 to 141), and that at three months postoperatively was 99 degrees (86 to 138).

When performing subgroup analysis between those with mild (<1.50 D) and severe astigmatism (≥1.50 D), we found a statistically significant difference between preoperative and postoperative astigmatism at one month ($p<0.001$) in the severe astigmatism group. This difference between preoperative and postoperative astigmatism remained statistically significant at three months postoperatively ($p<0.001$). The median preoperative astigmatism was 2.00 D, while at one month after surgery, the median astigmatism reduced to 1.50 D and remained at 1.50 D at three months postoperatively. The medians of the magnitude of SIA in this group were 0.67 D at one month, and 0.78 D at three months after surgery.

On the contrary, in the mild astigmatism group, there was no statistically significant difference between preoperative and postoperative astigmatism at one month ($p =0.97$), or between preoperative and postoperative astigmatism at three months ($p=0.83$). All of the medians of preoperative and postoperative astigmatism at both one month and three months were 0.75 D in this group (Figure 4). The median SIA magnitude in this group was 0.52 D at one month

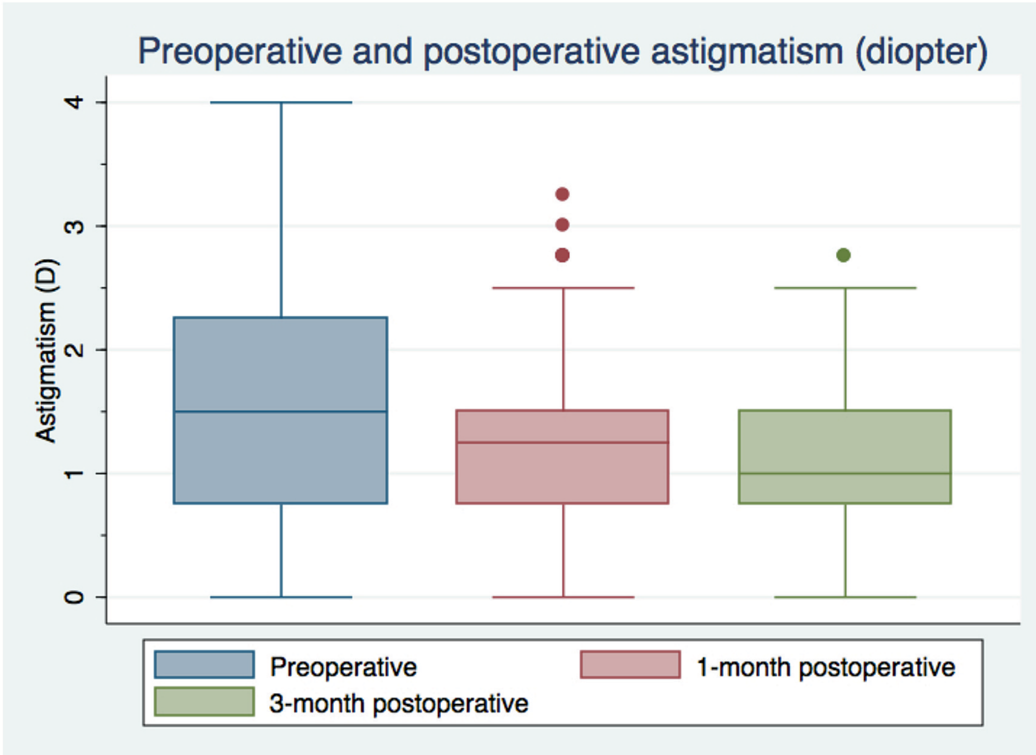

Figure 1. *Preoperative, 1-month and 3-month postoperative astigmatism (diopter)*

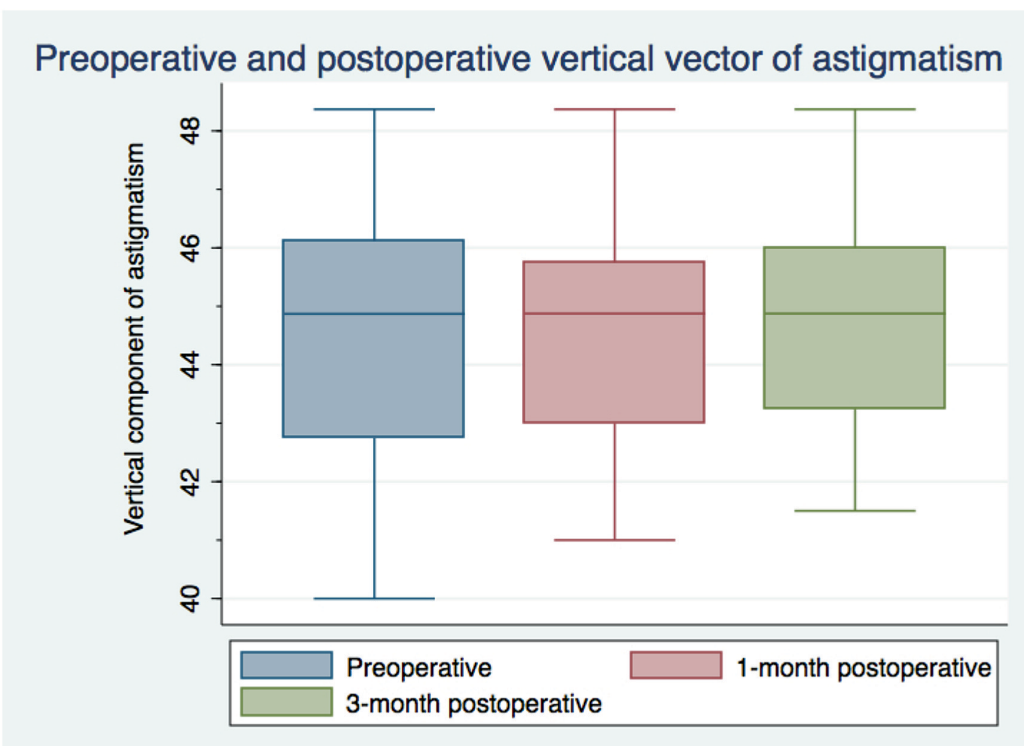

Figure 2. *Preoperative and postoperative vertical component (K1) of the vector analysis of astigmatism*

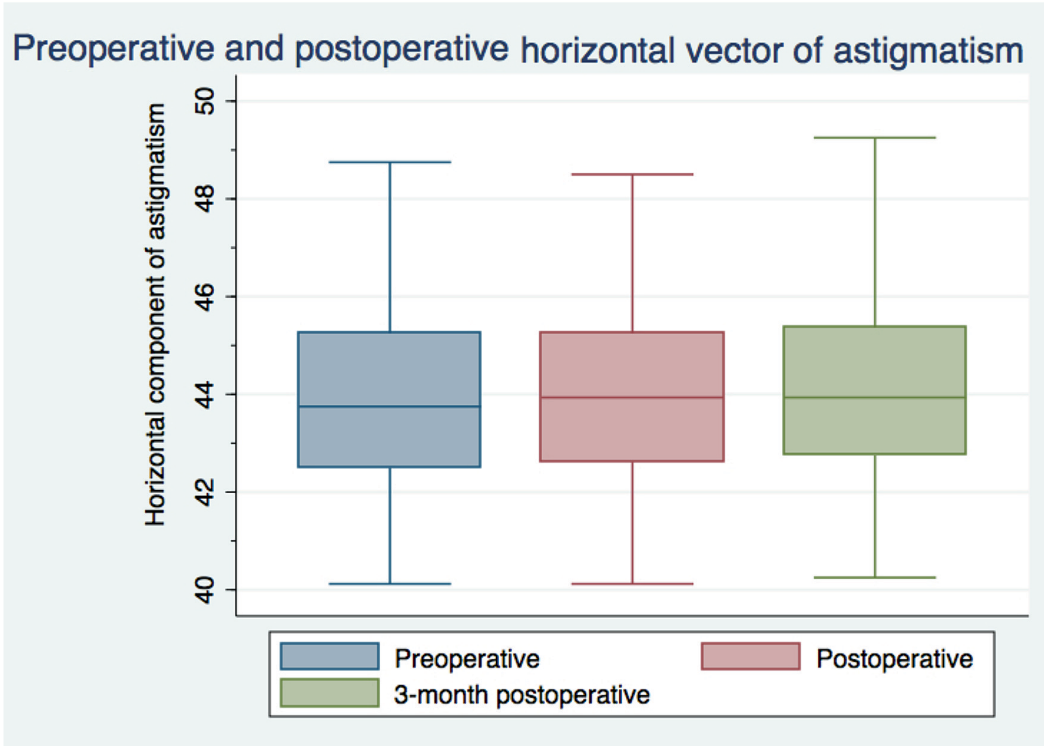

Figure 3. *Preoperative and postoperative horizontal component (K2) of the vector analysis of astigmatism*

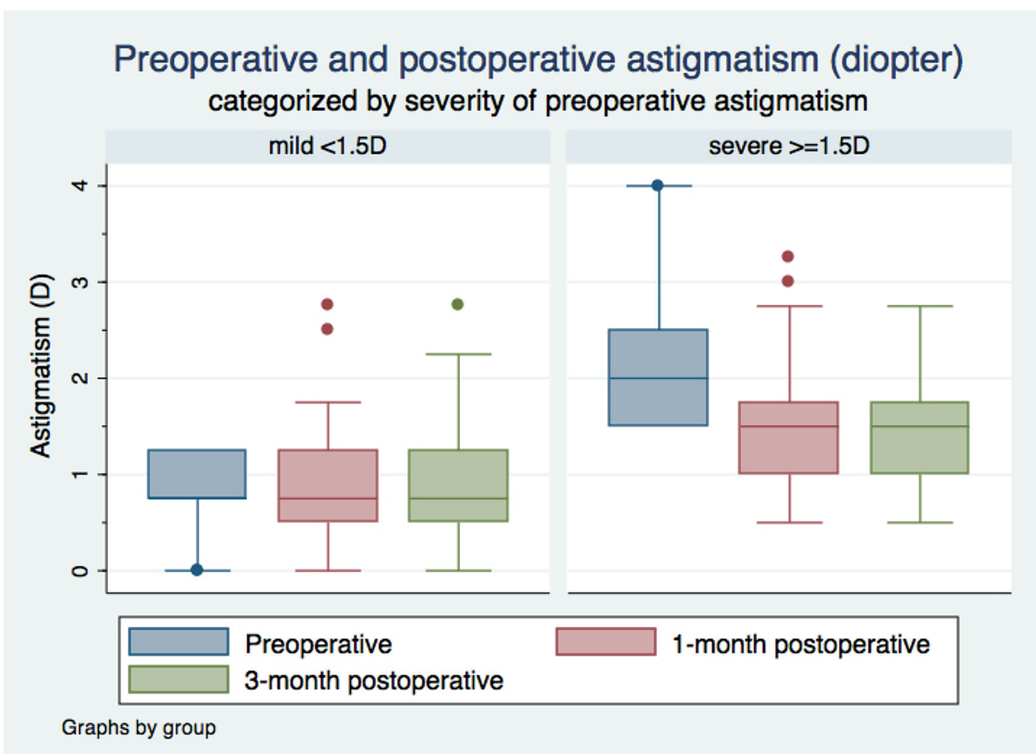

Figure 4. *Preoperative and postoperative astigmatism (diopter) categorized by severity of preoperative astigmatism*

postoperatively, and 0.55 D at three months postoperatively.

When comparing between the magnitude of SIA between the two groups, there was a statistically significant difference of SIA at 3 month postoperatively (0.78 D vs. 0.55 D; p=0.005). However, there was no significant difference of SIA at 1 month postoperatively (0.67 D vs. 0.52 D; p=0.13).

There was no significant change in preoperative and postoperative vertical (K1) and horizontal (K2) components in both groups (all p-value>0.05). In the mild astigmatism group, median preoperative, 1-month and 3-month postoperative K1 were 44.87, 44.63 and 44.5, respectively, and the corresponding values for K2 were 43.88, 44.12 and 44.19, respectively. For the severe astigmatism group, median preoperative, 1-month and 3-month postoperative K1 were 45.25, 45.31 and 45.38, respectively, and those of K2 were 43.69, 43.94 and 43.94, respectively.

Discussion

Clear corneal incisions have been widely used in cataract surgery because they can be self-resealed. However, clear corneal incisions may affect the curvature of cornea and cause surgically induced astigmatism. There are many factors responsible for surgically induced astigmatism such as the location and type of cataract incision, size, configuration of wound, suture material used, etc. Smaller size of incision, self-sealing wound as well as locating the incision as peripherally as possible to maximize the distance from the optical centre of the cornea lead to lesser astigmatism[7]. A temporal incision is advantageous because it can be made easily in deep sockets, small eyes or patients who have a large brow or nose bridge. Among these mentioned factors, the major factor responsible for post-operative astigmatism is the site of cataract incision[4,8]. An incision on the corneal causes flattening in the incised axis and steepening in the meridian 90 degrees away. Therefore, placing an incision on the steep axis of pre-existing astigmatism can increase the radius of curvature and reduce pre-existing astigmatism[4,9-11].

In this study, we showed that the technique of putting a clear corneal incision on the steepest axis decreased the magnitude of pre-existing astigmatism, particularly in patients with severe astigmatism (1.5 D or more). This effect was observed at both one month and three months postoperatively. In the mild astigmatism group (less than 1.5 D), there was almost no change in median of cylindrical power. There was one eye with no astigmatism. In this particular patient, temporal corneal incision was done and the SIA result was 0.13 D at 45 degree.

However, the vector analyses between preoperative and postoperative astigmatism did not find any significant difference in both the vertical (K1), and the horizontal (K2) components of astigmatism, neither in the whole study cohort nor in both subgroups.

We demonstrated that creating a clear corneal incision on the meridian of the steepest axis can improve spherical and astigmatic outcome. Nevertheless, there were some minor difficulties to operate along some axes, especially in cases of enophthalmos, large brow or nose bridge.

The efficiency in reducing astigmatism by making incision on the steepest meridian has already been addressed in many previous studies[2,9-12]. However, the astigmatism-reducing effects by incision on the steepest axis are not consistent, ranging from 0.20 D to 0.80 D[10,13,14]. We hypothesized that the effect would depend on the severity of astigmatism, in particular, more significant in eyes with higher degree of astigmatism. Some ophthalmologists prefer incisions on the steepest axis for patients with astigmatism of more than 1.50 D, and temporal or superior incisions for patients with minor degree of astigmatism (<1.50 D)[9]. In this study, we confirmed that the implication of surgically induced astigmatism on reducing pre-existing astigmatism can be used more effectively in patients with severe astigmatism of more than 1.5 D.

We used a 3.0-mm blade for a clear corneal incision, and this was found to produce higher SIA than other previous reports that used a keratome incision of 2.4-2.6 mm. Therefore, for larger amounts of astigmatism, using a large wound size should increase the SIA and may be advantageous if toric lenses are not used.

An opposite clear corneal incision was proposed by Lever and Dahan as making two clear corneal incisions, one on the steepest axis and the other on the opposite side (180^{o} from the first incision)[11]. Mukherjee and Muhtaseb found that opposite clear corneal incisions could reduce pre-existing astigmatism more effectively than a single incision at the steepest axis[9]. However, all patients in their study had more than 1.50 D of preoperative astigmatism.

Recent reports suggest that the post-cataract endophthalmitis rate may be substantially higher, suggesting a greater risk of endophthalmitis coincident with the increase in self-sealing clear corneal incisions[15]. Post-operative plan of care should be dealt with caution.

Strength and limitations

This is a retrospective study designed to evaluate the effect of a clear corneal incision on the steepest axis on reducing pre-existing astigmatism in different degrees of astigmatism. All operations were performed by the same surgeon, thus the technique of the incision would be consistent.

Nevertheless, this study has some limitations. We used a Canon RK-1 Autorefractor/ keratometer to measure K-values and refraction. In some patients who had dense posterior subcapsular cataract with severe visual impairment, the autorefractor/ keratometer might not measure K-values and refraction accurately because these patients could not focus on a target in the measurement procedure. Only a small area of the paracentral cornea (two points at the 3-4 mm zone) could be measured, and it would assume that the shape of the cornea is a symmetric spherocylinder with a major and minor axis separated by 90 degrees. The manual keratometry and the rotating Scheimpflug photography system (Pentacam) can provide accurate readings for most patients even with severe visual impairment[16,17]. Pentacam has also been the standard method for determining astigmatism for IOL calculation[18-21]. The use of the manual keratometry or Pentacam may provide more accurate measurement in further study.

Autorefraction was obtained with the patients sitting upright. Cyclotorsion can be induced in some individuals in the supine position[22]. A significant different range of cyclotorsion between the upright and the supine position was previously reported as varying from 2 to 7 degrees[23]. This study reduced amount of the cyclotorsion by undergoing retrobulbar anesthesia[24].

Conclusion

In conclusion, we showed that an incision on the steepest axis of an eye with pre-existing astigmatism can reduce astigmatism significantly in severe astigmatism over 1.50 D. A clear corneal incision at the steepest axis is beneficial in patients with severe astigmatism over 1.5 diopters who undergo a cataract surgery and can be an alternative option if toric lenses are not available.

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