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ORIGINAL RESEARCH

A Comparative Study of the Effect of Femtosecond Laser-Assisted Cataract Surgery on Corneal Astigmatism in Post-LASIK Eyes and Virgin Eyes

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Purpose: To evaluate and compare the effect of femtosecond laser-assisted cataract surgery on corneal astigmatism in post-LASIK eyes and virgin eyes.

Patients and Methods: Patients who underwent femtosecond laser-assisted cataract surgery were included in the study and categorized into two groups: Group A, consisting of patients with post-LASIK eyes, and Group B, consisting of patients with virgin eyes. Visual acuity, corneal astigmatism, and surgically induced astigmatism (SIA) were evaluated. Additionally, the correlation between SIA and preoperative corneal astigmatism, mean corneal curvature, and central corneal thickness was also analyzed.

Results: A total of 168 eyes were enrolled in this study, with 62 eyes in Group A and 106 eyes in Group B. Significant differences in corneal astigmatism and SIA were observed between the two groups in the early postoperative period following cataract surgery ($P<0.05$). However, there was no significant difference at 6 months postoperatively ($P>0.05$). Corneal astigmatism demonstrated an against-The-rule shift in both groups postoperatively. No significant correlation was identified between SIA and preoperative corneal astigmatism, corneal curvature or corneal thickness. Additionally, there was no significant difference observed between the two groups in terms of uncorrected distance visual acuity (UDVA) at 6 months postoperatively.

Conclusion: The effect of femtosecond laser-assisted cataract surgery on corneal astigmatism in post-LASIK eyes and virgin eyes was different in the early postoperative period. However, there was no significant difference at 6 months postoperatively. The post-LASIK eyes exhibited a delayed recovery compared to the virgin eyes.

Keywords: LASIK, femtosecond laser-assisted, cataract surgery, corneal astigmatism, surgically induced astigmatism

Introduction

Laser in situ keratomileusis (LASIK) is one of the widely performed types of refractive surgery.[1] Over time, a notable proportion of individuals who underwent LASIK have subsequently presented with cataract.[2,3] This trend has led to a considerable rise in the population of post-LASIK patients seeking cataract surgery.[4] These patients, accustomed to being spectacle independent following corneal refractive procedures, hold heightened expectations for achieving optimal uncorrected visual acuity (UCVA) after cataract surgery. The presence of significant astigmatism, whether preexisting or induced by the surgical intervention, can pose limitations the attainment of desired postoperative UCVA.[5]

Total astigmatism originates predominantly from two sources, one is corneal astigmatism and the other is intraocular astigmatism, primarily arising from the lens. Following cataract surgery, total astigmatism is primarily influenced by corneal astigmatism. Postoperative corneal astigmatism stands as a significant determinant of both postoperative vision and visual quality in cataract patients.[6] Hence, the correction of corneal astigmatism constitutes a crucial aspect of cataract surgery aimed at achieving optimal refractive outcomes. Postoperative corneal astigmatism is determined by the vectorial summation of preoperative corneal astigmatism and surgically induced astigmatism (SIA).[6] The SIA may either aggravate pre-existing corneal astigmatism or mitigate its magnitude.

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The utilization of femtosecond laser technology in modern microincision cataract surgery has become commercially available[7] and is increasing gaining popularity.[6] Femtosecond lasers enable precise customization of parameters associated with clear corneal incisions (CCIs), encompassing aspects such as width, length, location, and structural configuration.[8,9] This capability ensures predictable and reproducible surgical outcomes,[10] thereby enhancing the precision of corneal incision creation. Moreover, the application of femtosecond laser technology for lens fragmentation substantially reduces the requirement for intraoperative ultrasound energy and duration, thereby minimizing potential adverse effects on the corneal incision. Several studies have suggested that the integration of femtosecond laser technology has contributed to improved safety and efficacy in the management of corneal astigmatism during or following cataract surgery.[6,7]

In comparison to virgin eyes, post-Lasik eyes exhibit alterations in anterior corneal curvature and the anterior-to-posterior corneal relationships. Laser ablation procedures also impact corneal thickness, integrity, and regularity.[7] These changes may contribute to differences in corneal astigmatism between post-Lasik eyes and virgin eyes following femtosecond laser-assisted cataract surgery. As of our knowledge, there is a paucity of relevant studies or reports published in the literature addressing this specific concern. Hence, the objective of this study was to evaluate and compare the effect of femtosecond laser-assisted cataract surgery on corneal astigmatism in post-LASIK eyes and virgin eyes.

Patients and Methods

This retrospective study comprised individuals who underwent femtosecond laser-assisted cataract surgery between June 2022 and November 2023 at Hangzhou MSK Eye Hospital, Hangzhou, China. The study was approved by the Medical Ethics Committee of Hangzhou MSK Eye Hospital. Since the data are anonymous, were stored confidentially and the study was compliant with the Declaration of Helsinki, the requirement for informed consent was waived.

Patients meeting the following criteria were enrolled: (1) aged 18 years or older; (2) a history of femtosecond laser-assisted phacoemulsification cataract surgery; (3) completion of a 6-month follow-up period. Exclusion criteria comprised: (1) presence of ocular surface disorders such as severe dry eye, ectropion, entropion, or trichiasis; (2) concurrent ocular pathologies including corneal disease, uveitis, glaucoma, retinopathy, or neurological lesions; (3) history of ocular trauma or prior ocular surgeries, (4) absence of 6-month follow-up data.

Patients were stratified into distinct groups based on their history of LASIK surgery. Group A comprised individuals with a prior history of myopic excimer laser in situ keratomileusis preceding cataract surgery, with right eyes designated as Group A1 and left eyes designated as Group A2. Group B encompassed patients with virgin eyes, devoid of any history of corneal refractive surgery, with right eyes classified as Group B1 and left eyes as Group B2.

Clinical Data Measurement

All patients underwent a comprehensive preoperative ophthalmologic assessment within a timeframe of 2 weeks preceding cataract surgery. This evaluation encompassed a battery of assessments including measurement of uncorrected distance visual acuity (UDVA), corrected distance visual acuity (CDVA), manifest and cycloplegic refractions, keratometry, slit-lamp microscopy, intraocular pressure (IOP) measurement, endothelial cell density (ECD) assessment, ultrasound A and B scan, dilated indirect fundoscopy, anterior segment tomography (Sirius; CSO, Florence, Italy), biometry (IOL Master 700; Carl Zeiss, Jena, Germany), and optical coherence tomography (OCT) (Cirrus HD-OCT 5000; Carl Zeiss, Jena, Germany).

Follow-up assessments were scheduled at specific interval of 1 week, 1 month, 3 months and 6 months postoperatively. Parameters including uncorrected distance visual acuity (UDVA), corrected distance visual acuity (CDVA), and manifest refraction spherical equivalent (MRSE) were recorded. The AS-OCT evaluations were conducted under the supervision of the same experienced physician, ensuring consistency in methodology. Each eye underwent a minimum of three measurements, demonstrating robust reproducibility. Patients received measurements both preoperatively and postoperatively at 1 month and 6 months, with data extraction focusing on: (1) central corneal thickness (CCT); (2) central ketatomtry; (3) assessment of astigmatism magnitude and axis. Surgically induced astigmatism (SIA) vectors were calculated with the method described by Alpins & Goggin.[11] The mean absolute magnitudes of SIA vectors along with the centroid values were reported; (4) evaluation of corneal astigmatism axis shift (AS): denoting the angular disparity between preoperative and postoperative astigmatism vectors. Positive values indicate a clockwise rotation, whereas negative values indicate a counterclockwise rotation of the astigmatism vector.

Surgical Procedures

The femtosecond laser system (LenSx; Alcon, Fort Worth, TX, USA) was utilized for the execution of capsulorhexis, lens fragmentation, and creation of dual incisions comprising the main incision and lateral incision. A three-planar primary incision measuring 2.2mm in diameter was made at 180 degrees for right eyes and at 0 degrees for left eyes. Uniform femtosecond laser parameters were applied across all patients. Subsequent to the completion of femtosecond laser procedures, phacoemulsification combined with intraocular lens (IOLs) implantation was performed. Postoperative eyedrops including topical antibiotics and corticosteroids (levofloxacin, Santen, Japan, and Tobradex, Alcon, Fort Worth, TX, USA) were used. All surgical interventions were conducted by the same experienced surgeon.

Statistical Analysis

All statistical analyses were conducted using Microsoft Excel 2010 (Microsoft Corporation, Redmond, WA) and SPSS software (version 22.0, SPSS, Inc, USA). The Kolmogorov–Smirnov test was used to assess the normality of continuous variables. Normally distributed data were presented as means ± standard deviations (SD). Visual acuity data were converted to logMAR values. Categorical variables were presented as numbers and percentages. The independent-sample *t* test was used to compare the data between Group A and Group B in the presence of a normal distribution; otherwise, the Wilcoxon signed-rank test was applied. Spearman analysis was performed to determine the correlation between SIA and preoperative corneal astigmatism, corneal curvature, and central corneal thickness. Two-sided P value less than 0.05 was considered statistically significant.

Results

A total of 168 eyes were included in this study. Group A consisted of 62 eyes with a history of LASIK, subdivided into 33 right eyes (Group A1) and 29 left eyes (Group A2). Group B comprised 106 eyes with no history of LASIK, subdivided into 54 right eyes (Group B1) and 52 left eyes (Group B2). The baseline characteristics for each group are detailed in Table 1. All surgical procedures were uneventful, with no intraoperative or postoperative complications reported. An AS- OCT image of the 2.2mm clear corneal incision created by the femtosecond laser is shown in Figure 1.

Table 1 Patients' Baseline Demographic Data

Parameter	Group		P	Group		P
Eyes	Group A1 Group B1	33 54		Group A2 Group B2	29 52	
Age (years)	Group A1 Group B1	58.73±4.78 57.26±5.97	0.235	Group A2 Group B2	58.21±4.51 57.50±6.36	0.599
Mean K (D)	Group A1 Group B1	38.35±1.89 43.75±1.55	<0.000*	Group A2 Group B2	38.68±1.85 43.93±1.55	<0.000*
AL (mm)	Group A1 Group B1	27.00±2.02 24.09±1.87	<0.000*	Group A2 Group B2	26.77±2.10 23.82±1.76	<0.000*
CCT(μm)	Group A1 Group B1	484±36 544±35	<0.000*	Group A2 Group B2	490±37 545±34	<0.000*
IOP (mmHg)	Group A1 Group B1	11.19±2.17 14.04±2.50	<0.000*	Group A2 Group B2	11.70±1.99 14.10±2.44	<0.000*
ACD (mm)	Group A1	3.32±0.35	0.001*	Group A2	3.30±0.35	0.003*

(*Continued*)

Table 1 (Continued).

Parameter	Group		P	Group		P
	Group B1	3.06±0.32		Group B2	3.05±0.34	
LT(mm)	Group A1 Group B1	4.35±0.37 4.49±0.30	0.051	Group A2 Group B2	4.38±0.33 4.50±0.28	0.096
ECD (cells/mm^2)	Group A1 Group B1	2814 ± 178 2764 ± 174	0.875	Group A2 Group B2	2776 ± 165 2856 ± 164	0.853
MRSE (D)	Group A1 Group B1	−3.51±4.39 −1.35±4.31	0.027*	Group A2 Group B2	−2.91±4.09 −0.72±3.92	0.020*

Notes: * Significant difference between Groups (P< 0.05).
Abbreviations: K, corneal curvature; AL, axial length; CCT, central corneal thickness (µm); IOP, intraocular pressure; ACD, anterior chamber depth; LT, lens thickness; ECD, endothelial cell count; MRSE, mean refractive spherical equivalent.

Visual Acuity

Table 2 presents the visual outcomes for each group at various follow-up intervals. The distribution of UDVA for different groups at 6 months after cataract surgery is illustrated in Figure 2. At this time point, the percentage of eyes achieving an uncorrected distance visual acuity of 20/20 was 75% for group A1, 78% for group B1, 71% for Group A2, and 77% for Group B2. Furthermore, 85% of eyes in group A1, 94% in group B1, 88% in Group A2, and 100% in Group B2 achievied an uncorrected distance visual acuity of 20/25. The percentage of eyes reaching an uncorrected distance visual acuity of 20/40 was 100% across all groups, as detailed in Table 3. There were no statistically significant differences in UDVA between Group A and Group B at 6 months postoperatively.

Corneal Astigmatism

Table 4 presents the corneal astigmatism values over different corneal zones at each follow-up for different groups. Preoperatively, there was no significant difference in corneal astigmatism between the post-LASIK eyes and the virgin eyes (P>0.05). In virgin eyes, mean corneal astigmatism remained consistent across different corneal zones. However, in post-LASIK eyes, astigmatism values appeared to increase with the size of the corneal zone, although this trend was not statistically significant (P>0.05).

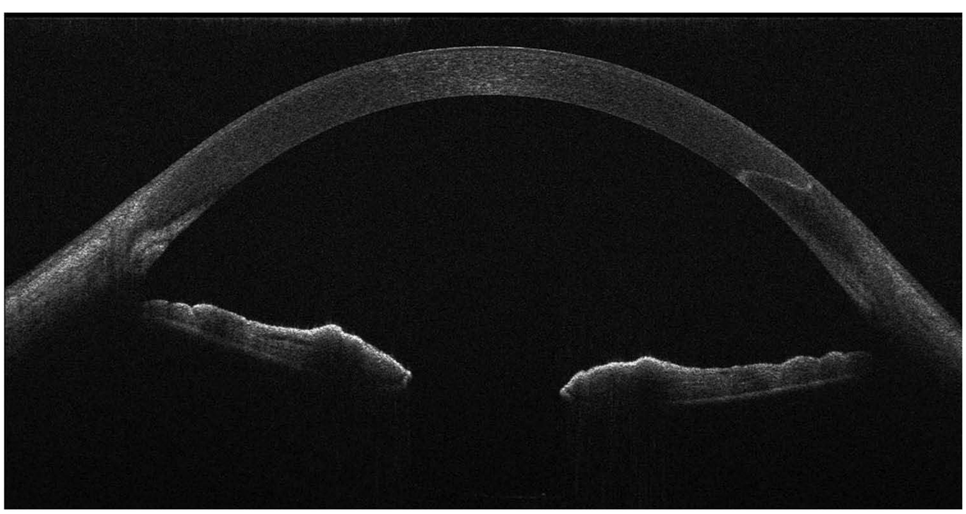

Figure 1 AS- OCT image of 2.2mm clear corneal incision created by the femtosecond laser.

Table 2 Changes in Preoperative and Postoperative Uncorrected Distance Visual Acuity (LogMAR, Mean±SD)

Time	Group	UDVA	P	Group	UDVA	P
Pre-Op	Group A1 Group B1	0.63±0.62 0.60±0.61	0.841	Group A2 Group B2	0.49±0.52 0.49±0.54	0.960
Post-Op 1w	Group A1 Group B1	0.03±0.12 0.02±0.08	0.010*	Group A2 Group B2	0.05±0.15 −0.00±0.11	0.071
Post-Op 1m	Group A1 Group B1	0.03±0.12 −0.02±0.08	0.050	Group A2 Group B2	0.04±0.15 0.01±0.09	0.073
Post-Op 3m	Group A1 Group B1	0.01±0.09 −0.02±0.08	0.160	Group A2 Group B2	0.03±0.11 −0.02±0.06	0.018*
Post-Op 6m	Group A1 Group B1	0.01±0.11 0.01±0.11	0.372	Group A2 Group B2	−0.01±0.09 −0.02±0.06	0.123

Notes: * Significant difference between Groups (P< 0.05).
Abbreviations: UDVA, uncorrected distance visual acuity; Pre-Op, preoperative; Post-Op, postoperative; 1w, 1 week; 1m, 1 month; 3m, 3 months; 6m, 6 months; SD, standard deviation.

Statistically significant differences in corneal astigmatism were observed between Group A1 and Group B1, and between Group A2 and Group B2, at 1 month postoperatively (p < 0.05). However, at 6 months postoperatively, there were no significant differences between Group A and Group B, except in the 6mm corneal zone for Group A2 and Group B2. In Group A, the magnitude of corneal astigmatism was significantly higher at 1 month postoperatively compared to preoperative level, but it decreased by 6 months postoperatively, essentially returning to preoperative levels, with no significant difference compared to the preoperative levels (P>0.05). In Group B, corneal astigmatism remained stable, with no significant differences between preoperative and postoperative measurements (Figure 3).

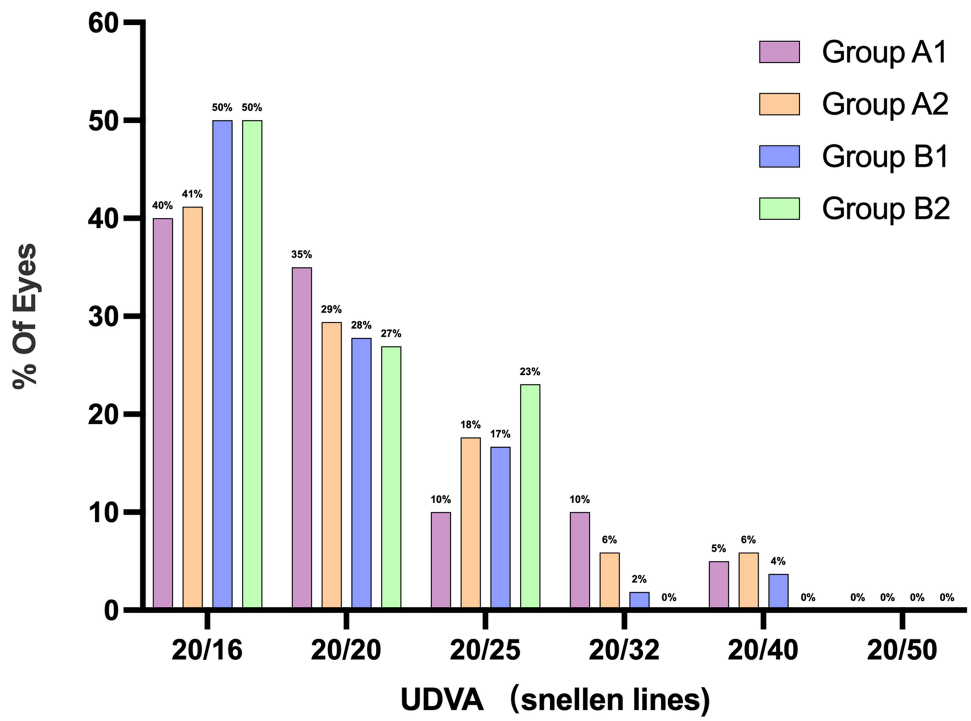

Figure 2 Distribution of uncorrected distance visual acuity (UDVA) for different groups at 6 months after cataract surgery.

Table 3 Proportions of Eyes with Different UDVA Levels at Postoperative 6 Months

UDVA	Group	Proportion	P	Group	UDVA	P
≥20/40	Group A1 Group B1	100% 100%	>0.999	Group A2 Group B2	100% 100%	>0.999
≥20/25	Group A1 Group B1	85% 94%	0.334	Group A2 Group B2	88% 100%	0.058
≥20/20	Group A1 Group B1	75% 78%	0.801	Group A2 Group B2	71% 77%	0.747

Abbreviation: UDVA, uncorrected distance visual acuity.

Table 4 Changes in Corneal Astigmatism

Time	Corneal Zone	Group	Corneal Astigmatism	P	Group	Corneal Astigmatism	P
Pre-Op	4mm	Group A1	0.59±0.62	0.669	Group A2	0.58±0.34	0.356
		Group B1	0.54±0.26		Group B2	0.53±0.24	
	6mm	Group A1	0.69±0.41	0.111	Group A2	0.63±0.39	0.217
		Group B1	0.54±0.26		Group B2	0.54±0.30	
Post-Op 1m	4mm	Group A1	0.80±0.48	0.025*	Group A2	0.79±0.54	0.018*
		Group B1	0.60±0.33		Group B2	0.56±0.27	
	6mm	Group A1	0.96±0.50	0.000*	Group A2	0.97±0.64	0.000*
		Group B1	0.57±0.38		Group B2	0.60±0.27	
Post-Op 6m	4mm	Group A1	0.59±0.29	0.944	Group A2	0.62±0.34	0.290
		Group B1	0.59±0.34		Group B2	0.53±0.27	
	6mm	Group A1	0.69±0.41	0.168	Group A2	0.70±0.43	0.036*
		Group B1	0.56±0.34		Group B2	0.52±0.26	

Notes: * Significant difference between Groups (P< 0.05).
Abbreviations: Pre-Op, preoperative; Post-Op, postoperative; 1m, 1 month; 6m, 6 months.

There was no statistically significant difference in the astigmatism axis shift between Group A and Group B (Table 5). In the right eye, astigmatism rotated clockwise, while in the left eye, it rotated counterclockwise, indicationg that astigmatism in both eyes shifted against the rule. On average, the astigmatism axis shift (AS) was approximately 10 degrees at 6 months postoperatively compared to preoperative measurements.

Surgically Induced Astigmatism

Figure 4 displays double-angle vector diagrams of SIA over different corneal zones at each follow-up interval for different groups. In Group A, SIA was more dispersed at 1 month postoperatively but showed a tendency to concentrate by 6 months postoperatively. The magnitude of SIA was greater over the 6mm corneal zone compared to the 4mm zone. Similarly, in Group B, SIA was more dispersed at 1 month postoperatively but became more concentrated by 6 months postoperatively. However, the magnitude of SIA did not differ significantly between the 4mm and 6mm corneal zones in Group B.

Table 6 presents the values of SIA over different corneal zones at each follow-up for groups. Both the absolute magnitude of SIA and the vector centroid values decreased at 6 months postoperatively compared to 1 month post-operatively in both groups. Post-LASIK eyes exhibited larger SIA in the 6mm corneal zone than in the 4mm zone. Conversely, in virgin eyes, the difference in SIA between the 6mm and 4mm corneal zones was not significant. Comparing the two groups, there was a significant difference in the mean absolute SIA at 1 month postoperatively, but no statistically significant difference at 6 months postoperatively in the 4mm corneal zone.

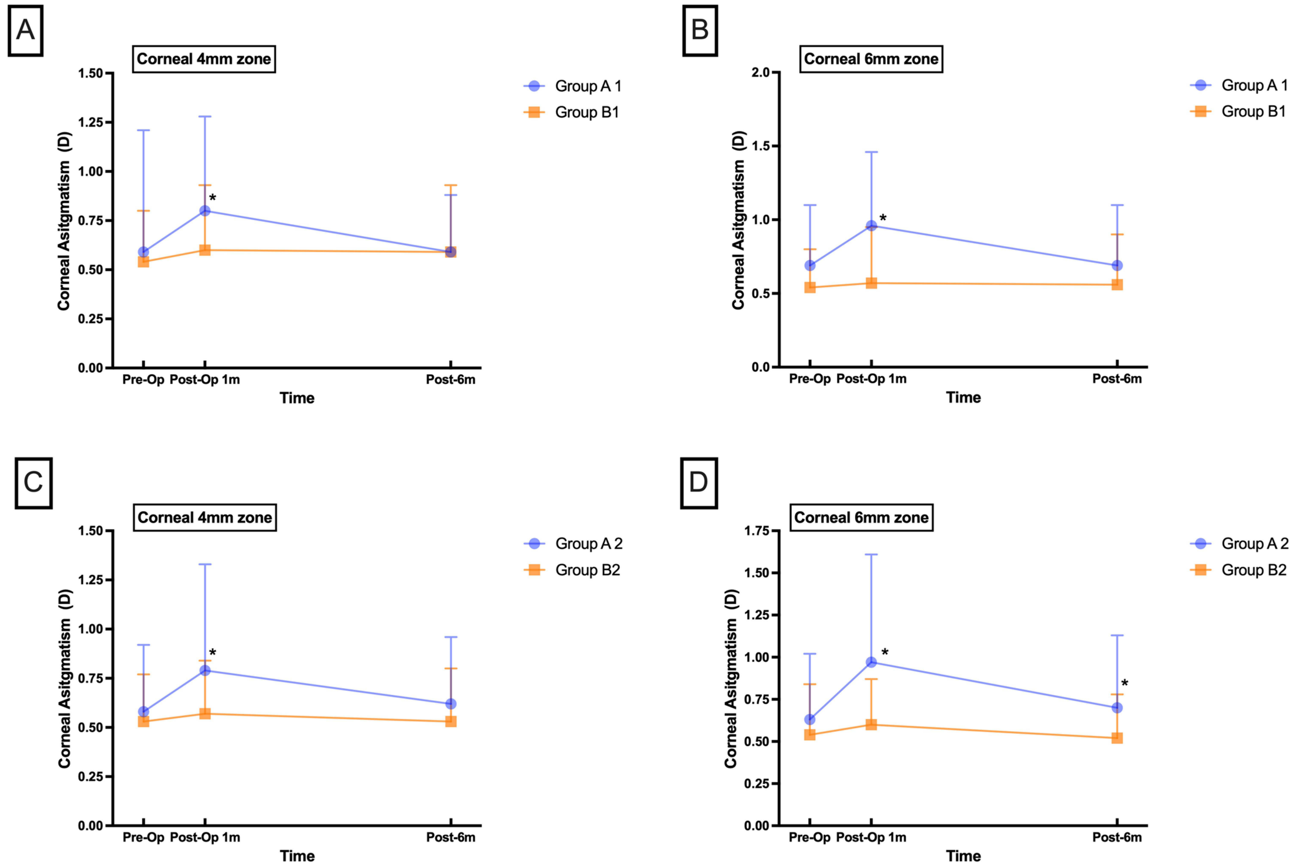

Figure 3 Changes in corneal astigmatism over different corneal zones for different groups during time. **(A)** for Group A1 and Group B1 over corneal 4mm zone.**(B)** for Group A1 and Group B1 over corneal 6mm zone.**(C)** for Group A2 and Group B2 over corneal 4mm zone.**(D)** for Group A2 and Group B2 over corneal 6mm zone.
Notes: *Significant difference between the two groups (P<0.05).
Abbreviations: Pre-Op, preoperative; Post-Op, postoperative.

Correlation Between SIA and Preoperative Corneal Astigmatism, Corneal Curvature, Central Corneal Thickness

Table 7 presents the results of the correlation analysis between SIA and preoperative corneal astigmatism, mean corneal curvature, and central corneal thickness at 1 month and 6 months postoperatively. The analysis revealed no statistically significant correlations between SIA and any of these preoperative parameters.

Table 5 Corneal Astigmatism Axis Shift

Time	Corneal Zone	Group	Axis Shift	P	Group	Axis Shift	P
Pre-Op vs Post-Op 1m	4mm	Group A1	16.0±77.5	0.885	Group A2	−19.2±94.0	0.205
		Group B1	13.7±67.7		Group B2	5.4±74.9	
	6mm	Group A1	−6.3±88.2	0.051	Group A2	−36.1±81.3	0.105
		Group B1	26.9±66.2		Group B2	−6.1±77.1	
Pre-Op vs Post-Op 6m	4mm	Group A1	12.0±57.9	0.880	Group A2	9.1±79.6	0.280
		Group B1	10.2±39.0		Group B2	−13.2±74.1	
	6mm	Group A1	5.9±83.5	0.735	Group A2	−13.1±70.7	0.960
		Group B1	11.6±54.1		Group B2	−13.9±53.6	

Abbreviations: Pre-Op, Preoperative; Post-Op, Postoperative; 1m, 1 month; 6m, 6 months.

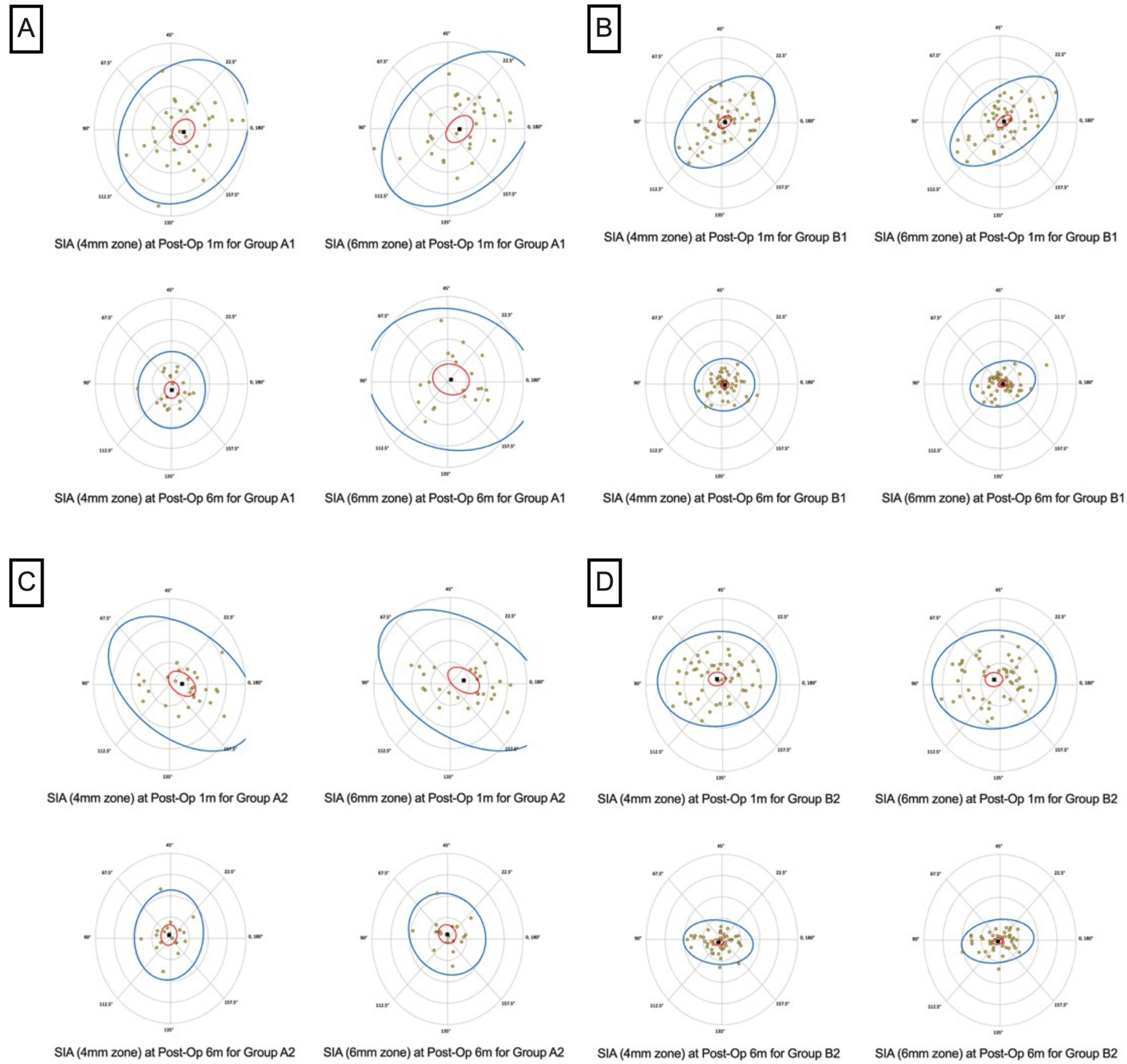

Figure 4 Double-angle vector diagrams of SIA over different corneal zones for different groups at 6 months postoperatively. (**A**) for Group A1; (**B**) for Group B1; (**C**) for Group A2; (**D**) for Group B2. The coordinates of SIA for each eye are shown with yellow dots, and centroid values are shown with black squares. Red cycle means 95% confidence ellipse of the centroid. Blue cycle means 95% confidence ellipse of the dataset. Each ring=0.50D.
Abbreviations: SIA, surgically induced astigmatism; Post-Op, postoperative.

Discussion

In patients with a history of LASIK, corneal curvature, corneal thickness, and corneal biomechanics are altered due to the effects of laser ablation. When these patients undergo cataract surgery, the changes in postoperative corneal astigmatism and SIA may differ compared to those in virgin eyes. This study found significant differences in corneal astigmatism and SIA between the two groups in the early postoperative period (P<0.05). However, by 6 months postoperatively, these differences were no longer significant (P>0.05). Postoperative corneal astigmatism shifted in an against-The-rule direction for both groups. Additionally, no significant correlations were observed between SIA and preoperative corneal astigmatism, corneal curvature or corneal thickness. There was also no significant difference in UDVA between the two groups at 6 months postoperatively.

Table 6 SIA for Group a and Group B

Time	Corneal zone	Parameter	Group A1	Group B1	P
Post-Op 1m	4mm	Centroid (magnitude @axis)	0.33D @ 176°± 0.91D	0.09D @ 6°± 0.67D	
		Mean Absolute	0.86D±0.44D	0.58D±0.33D	0.001*
	6mm	Centroid (magnitude @axis)	0.31D @ 179°± 1.03D	0.10D @ 7°± 0.68D	
		Mean Absolute	0.97±0.44	0.59±0.35	<0.000*
Post-Op 6m	4mm	Centroid (magnitude @axis)	0.14D @ 137°± 0.46D	0.08D @ 174°± 0.39D	
		Mean Absolute	0.43D±0.19D	0.33D±0.21D	0.072
	6mm	Centroid (magnitude @axis)	0.11D @ 16°± 1.02D	0.06D @ 2°± 0.40D	
		Mean Absolute	0.90D±0.44D	0.33D±0.22D	<0.000*
Time	**Corneal zone**	**Parameter**	**Group A2**	**Group B2**	**P**
Post-Op 1m	4mm	Centroid (magnitude @axis)	0.33D @ 1°± 0.95D	0.20D @ 69°± 0.74D	
		Mean Absolute	0.84D±0.53D	0.70D±0.30D	0.138
	6mm	Centroid (magnitude @axis)	0.36D @ 6°± 1.05D	0.20D @ 72°± 0.77D	
		Mean Absolute	0.95D±0.55D	0.73D±0.32D	0.027*
Post-Op 6m	4mm	Centroid (magnitude @axis)	0.09D@ 60°±0.51D	0.12D@ 107°±0.41D	
		Mean Absolute	0.42D±0.29D	0.37D±0.22D	0.421
	6mm	Centroid (magnitude @axis)	0.12D @48°±0.51D	0.06D@ 101°±0.42D	
		Mean Absolute	0.43D±0.27D	0.36D±0.22D	0.288

Notes: *Significant difference between Groups (P< 0.05).
Abbreviations: SIA, Surgically induced astigmatism vector; Pre-Op, Preoperative; Post-Op, postoperative; 1m, 1month; 6m, 6 months.

Table 7 Correlation Analysis Between SIA and Preoperative Corneal Astigmatism, Corneal Curvature, Central Corneal Thickness

Time	SIA (Corneal zone)	Preoperative Corneal Astigmatism			
		Group A1	Group A2	Group B1	Group B2
Post-Op 1m	4mm	0.808	0.694	0.754	0.792
	6mm	0.925	0.905	0.892	0.792
Post-Op 6m	4mm	0.390	0.784	0.612	0.425
	6mm	0.055	0.254	0.165	0.607
Time	**SIA (Corneal zone)**	**Mean K**			
		Group A1	Group A2	Group B1	Group B2
Post-Op 1m	4mm	0.859	0.676	0.561	0.623
	6mm	0.923	0.906	0.866	0.323
Post-Op 6m	4mm	0.743	0.601	0.193	0.714
	6mm	0.911	0.916	0.095	0.658
Time	**SIA (Corneal zone)**	**CCT**			
		Group A1	Group A2	Group B1	Group B2
Post-Op 1m	4mm	0.462	0.936	0.517	0.711
	6mm	0.551	0.688	0.706	0.544
Post-Op 6m	4mm	0.978	0.567	0.332	0.291
	6mm	0.203	0.748	0.665	0.773

Abbreviations: SIA, Surgically induced astigmatism vector; K, corneal curvature; CCT, Central corneal thickness (μm); Post-Op, Postoperative; 1m, 1 month; 6m, 6 months.

At 1 month postoperatively, corneal astigmatism in eyes with prior LASIK surgery exhibited a significantly greater magnitude and dispersion compared to preoperative level. However, by 6 months postoperatively, corneal astigmatism demonstrated a gradual reduction, accompanied by a tendency towards increased concentration. Conversely, corneal astigmatism in virgin eyes remained relatively stable and concentrated at both 1 and 6 months postoperatively. These findings suggest a more pronounced impact of femtosecond laser-assisted cataract surgery on corneal astigmatism in post-LASIK eyes compared to virgin eyes, with post-LASIK eyes requiring an extended duration for corneal healing and stabilization. This disparity may be attributed to the alterations induced by LASIK surgery, resulting in corneal thinning and biomechanical weakening subsequent to central central corneal ablation. However, further comprehensive investigations with larger sample sizes are warranted to validate these observations.

Furthermore, we observed alterations in the axial orientation of corneal astigmatism. Our findings revealed a clockwise rotation of corneal astigmatism in the right eye and a counterclockwise rotation in the left eye following surgery in both groups. This indicates a consistent shift towards an against-The-rule direction in both eyes, with an average rotation of 10 degrees. However, notable individual variability was observed, emphasizing the necessity for further investigation with a larger sample size to validate these observations.

Surgically induced astigmatism (SIA) is characterized as the disparity between postoperative and preoperative astigmatism. SIA is influenced by various factors including the location, width, length, and shape of the incision.[12,13] In this study, the lenSx femtosecond laser was utilized to create a 2.2-mm clear corneal primary incision positioned at 180° axial orientation for the right eye and 0° axial orientation for the left eye. Uniform femtosecond setup parameters were employed for all patients to mitigate potential confounding factors such as variations in incision position, size, and shape. Additionally, surgical procedures were consistently performed by the same experienced surgeon to minimize the impact of operator skill and experience on SIA.

We calculated both the mean absolute value and the centroid value of the SIA. While the mean absolute value indicates the magnitude of SIA without considering its direction, the vector centroid value, as suggested by Holladay et al[14] incorporates the direction of each vector and may offer a more comprehensive representation of the overall sample. However, it may underestimate SIA magnitude when the distribution is excessively dispersed.[15] Considering the distribution and changes in SIA observed in our patient cohort, we posit that the SIA vector centroid holds greater clinical significance than the absolute mean value.

In the case of temporal incisions, both post-LASIK and virgin eyes experienced approximately 0.10D of SIA induced by the femtosecond laser-assisted incisions, resulting in a postoperative corneal astigmatism shift against the rule compared to preoperative values. These findings align with those of Alpins et al[16] who recommended accounting for the flattening effect of corneal incisions in the calculation of toric intraocular lenses (IOLs). Specifically, for temporal incisions, the flattening effect of femtosecond laser-assisted incisions was measured at −0.11D.

Patients with a history of myopia LASIK exhibit characteristic ocular parameters including flatter corneal curvature, longer axial length, thinner corneal thickness, and deeper anterior chamber depth. In this investigation, we conducted a correlation analysis to assess the relationship between surgically induced astigmatism (SIA) and preoperative corneal astigmatism, corneal curvature, and corneal thickness in both post-LASIK and virgin eyes. Our analysis revealed no statistically significant correlation between these factors in either group. However, previous research by Ferreira et al[16] identified correlations between SIA and several preoperative parameters, including preoperative astigmatism (positive correlation), preoperative corneal curvature (where flatter corneas exhibited greater SIA), anterior chamber depth (where deeper chambers correlated with lesser SIA), axial length (where longer eye axes correlated with greater SIA), and transverse corneal diameter (where smaller corneas correlated with greater SIA). Nonetheless, it is crucial to note that these correlations were observed to be weak, underscoring the inherently unpredictable nature of SIA as a variable.

Variations in surgically induced astigmatism (SIA) and corneal astigmatism between the patient groups may contribute to discrepancies in visual acuity outcomes. Initial assessments at 1 week postoperatively revealed slightly superior uncorrected distance visual acuity (UDVA) in right virgin eyes compared to post-LASIK eyes, while at 3 months postoperatively, UDVA in left post-LASIK eyes demonstrated a slight decrement compared to virgin eyes. By the 6-month follow-up, no statistically significant disparity in visual acuity existed between the two groups, with all patients achieving UDVA ≥0.5. Consequently, post-LASIK eyes exhibited marginally delayed visual recovery in the early postoperative phase, potentially attributable to greater SIA. However, as corneal astigmatism gradually diminished with corneal recovery over time, visual acuity differences became negligible in the late postoperative period.

The current study has several limitations. Firstly, the cohort consisted predominantly of patients with mild to moderate preoperative corneal astigmatism. The prevalence and presentation patterns of corneal astigmatism in cataract surgery candidates have been reported by teams from different populations.[17–21] Yuan's[17] study for patients from northern China has revealed that 53.3% of eyes exhibited corneal astigmatism ≤1.00D, 33.7% displayed corneal astigmatism ranging from 1.00 to 2.00D, and 13.0% exhibited astigmatism exceeding 2.00D. The impact of cataract surgery on corneal astigmatism in patients with higher levels of astigmatism, particularly exceeding 1.50D, merits further investigation. Secondly, in cases of elevated preoperative corneal astigmatism, surgeons often opt for incisions at the steep axis. Such incision placement may induce distinct changes in corneal astigmatism postoperatively, particularly in post-LASIK eyes. Consequently, the specific alterations in corneal astigmatism induced by these incisions in post-LASIK eyes necessitate further exploration. Thirdly, comprehensive studies with larger sample sizes encompassing post-LASIK eyes are imperative to accurately quantify surgically induced astigmatism (SIA) resulting from corneal incisions oriented along different axial directions. These investigations would contribute substantially to our understanding of the nuanced effects of cataract surgery in this population.

Conclusion

The effect of femtosecond laser-assisted cataract surgery on corneal astigmatism in post-LASIK eyes and virgin eyes was different in the early postoperative period. However, there was no significant difference at 6 months postoperatively. The post-LASIK eyes exhibited a delayed recovery compared to the virgin eyes.

Data Sharing Statement

The data used during the current study are available from the corresponding author on reasonable request.

Ethics Approval and Consent to Participate

This retrospective study was approved by the Medical Ethics Committee of Hangzhou MSK Eye Hospital. The data are anonymous, confidential and the study was in compliance with the Declaration of Helsinki, so the requirement for informed consent was waived.

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Disclosure

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