Am J Transl Res 2023;15(3):2065-2074
www.ajtr.org /ISSN:1943-8141/AJTR0148448

Original Article

FLACS combined with IOLI is comparable to Phaco combined with IOLI in cataract patients after refractive surgery

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Received December 13, 2022; Accepted February 11, 2023; Epub March 15, 2023; Published March 30, 2023

Abstract: Objective: To characterize the clinical features of cataract surgery performed after refractive surgery. Methods: In this study, 23 patients with cataracts (38 eyes) who underwent cataract surgery following refractive surgery at the Shenzhen Aier Eye Hospital between the years 2017 and 2021 were retrospectively included for analysis. The patients had either femtosecond laser-assisted cataract surgery (FLACS) combined with intraocular lens implantation (IOLI), or conventional phacoemulsification (Phaco) combined with IOLI. The type and power of an intraocular lens (IOL) were selected based on the ocular condition, needs, and living habits of patients. Intraoperative complications, postoperative intraocular pressure (IOP), uncorrected visual acuity (UCVA), and postoperative refractive status were all recorded and analyzed. Results: The patients had a postoperative UCVA that was significantly better than the baseline (prior to operation), a postoperative IOP and diopter (D) similar to the baseline and a high level of postoperative satisfaction. The postoperative visual acuity, D and complication rate of FLACS+IOLI group were not significantly different from those of Phaco+IOLI group, and the IOP of the former was statistically lower than that of the latter. Conclusions: FLACS with IOLI or conventional Phaco with IOLI is feasible for cataract patients who have undergone refractive surgery. In terms of IOL selection, multifocal, extended range of vision (ERV), or trifocal types can be selected to achieve the goal of lens removal after surgery, but the decision should be made based on the patient's specific eye condition, living needs, and economic circumstances. To achieve satisfactory curative effects, it is necessary to have a comprehensive understanding of the characteristics of the condition of such patients, to master the pre- and post-operative diagnosis and treatment methods, to accurately calculate the IOLP, to fully communicate with patients about their surgical expectations, and to develop feasible surgical plans.

Keywords: FLACS, refractive surgery, multifocal, radial keratotomy

Introduction

Cataracts are the most common reversible cause of visual impairment and blindness worldwide. According to the most recent estimate, cataracts account for 51% (approximately 20 million people) of global blindness. Consequently, cataracts remain the leading cause of blindness. They can only be removed surgically [1]. Cataract surgery is a common and effective ophthalmic procedure that enables rapid visual recovery [2]. Due to advances in surgical techniques and instruments, cataract and refractive surgical procedures are now among the most common eye surgeries. As more and more patients undergoing refractive surgery develop cataracts, it has become increasingly critical to have a comprehensive understanding of the current state and future trends in these fields [3].

It is estimated that approximately 20 million cataract surgeries are performed annually worldwide [4]. The global burden of cataracts and, consequently, the demand for cataract surgery, is expected to increase substantially as the proportion of the world's ageing population increases. Moreover, as techniques and technologies (e.g. lens and phacoemulsification technologies) advance, there is a growing demand for perfect vision following cataract surgery [5].

Since radial keratotomy (RK) was first used to treat refractive errors in 1974, other refractive error correction procedures have been gradually introduced into clinical practice, including photorefractive keratectomy (PRK), laser *in situ* keratomileusis (LASIK), femtosecond LASIK [6], small incision lenticule extraction (SMILE), and implantable collamer lens (ICL) implantation. There is increasing acceptance and support for refractive surgery among the general population. The procedure of refractive surgery is widely accepted, recognized, and carried out throughout the world. Many patients who undergo early refractive surgery develop cataracts as they age. So the number of patients diagnosed with cataracts is expected to rise over time. According to clinical experience and published literature, the conventional intraocular lens (IOL) calculation formula is likely to result in hyperopia between 1.00 and 6.00 diopters in such patients [7]. Following refractive surgery, the unique characteristics of the cornea and eye necessitate new requirements for intraocular lens power (IOLP) selection and surgical skills.

Most of the current studies focus only on the prediction of IOL, with limited analytical research on postoperative visual acuity (VA), intraocular pressure (IOP), diopter (D), complications and related surgical characteristics in patients undergoing cataract surgery after refractive surgery. Thus, we performed related investigations through a retrospective analysis of the medical records and procedures of 23 patients with cataracts (38 eyes). The novelty of this study lies in the analysis of cataract surgery patients after refractive surgery from the perspectives of postoperative VA, IOP, D, complications and related surgical characteristics, which fills in relevant gaps and provides new insights for patients' surgical selection, IOL selection and postoperative recovery, with certain clinical significance for further optimizing the operation management of such a patient population.

Participants and methods

Study population

The Shenzhen Aier Eye Hospital Ethics Committee, affiliated to Jinan University, granted approval for this study. Consecutive cases involving 23 patients (38 eyes) who underwent cataract surgery following refractive surgery at the Shenzhen Aier Eye Hospital Affiliated to Jinan University between 2017 and 2022 were selected and retrospectively reviewed. These patients included 18 males (30 eyes) and 5 females (8 eyes), with a mean age of 50.3±7.2 years (range: 39-65), and a mean course of disease of 4.9±2.5 years; diabetes mellitus was confirmed in 11 cases and hypertension in 8 cases. Cataract surgery of the aforementioned patients was performed between 1 and 29 years after refractive surgery, and the post-cataract surgery follow-up period ranged from 1 week to 2 years. Inclusion criteria: cataract surgery after refractive surgery; no cognitive or mental abnormalities; complete medical records. Exclusion criteria: other ocular diseases; malignant tumors or serious diseases of other organs; contraindications for cataract surgery; infectious diseases; women during pregnancy or lactation.

Methods

Inspection methods: Preoperative evaluations and measurements included VA, IOP, IOLP (measured by IOL-Master 500 or OA2000), B-ultrasound of the eyes, anterior segment photography, and posterior segment optical coherence tomography (OCT). During postoperative follow-up, VA, IOP, D, and complications were primarily recorded.

Surgical methods: The patients selected either femtosecond laser-assisted cataract surgery (FLACS) with IOL implantation (IOLI) or conventional phacoemulsification (Phaco) with IOL implantation based on their eye conditions and economic status. FLACS with IOLI was performed using the LenSx FLACS system (Alcon Company, USA) and the Centurion Phaco machine (Alcon Company, USA). The patient was fully dilated prior to surgery and topical anesthesia. On the LenSx femtosecond laser operating platform, the main and side incisions, as well as the pre-chopping laser parameters and modes were set, and the PI (patient contact device) was installed. The negative pressure suction device was set to contact the surface of the eyeball after the patient was instructed to look at the laser device's guide lamp. Then, negative pressure suction was initiated to fix the eyeball and scan the eye structure, followed by laser emission to complete the

Table 1. Basic information of patients

Refractive surgery methods	Gender	Age (years)	Preoperative visual acuity (logMAR)	Preoperative IOP (mmHg)	Corneal curvature (D)	Axial length (mm)
LASIK (24 eyes, n=15)	M: 13 (86.7) F: 2 (13.3)	46.3±5.0	0.9±0.7	11.5±2.8	K1=38.5±1.8 K2=39.5±1.7	27.4±2.0
LASIK+PRK (1 eye, n=1)	M: 1 (100.0)	40	0.5	8	K1=35.3 K2=36.3	26.93
RK (10 eyes, n=5)	M: 3 (60.0) F: 2 (40.0)	54.6±5.7	0.8±1.1	17.5±2.3	K1=35.7±2.9 K2=36.9±3.0	26.6±2.2
ICL (3 eyes, n=2)	M: 1 (50.0) F: 1 (50.0)	52.7±2.3	0.4±0.2	13.3±2.5	K1=45.4±3.0 K2=46.2±2.6	26.7±5.0
Chi-square/F value	2.82	7.87	0.40	13.25	83.09	0.31
P value	0.42	<0.001	0.75	<0.001	<0.001	0.81

Note: LASIK, laser in situ keratomileusis; PRK, photorefractive keratectomy; RK, radial keratotomy; ICL, implantable collamer lens; IOP, intraocular pressure.

procedure. The patient underwent Phaco after the negative pressure was released. Following routine disinfection and the opening of the main and side incisions with a mouth opener, the anterior chamber was injected with a viscoelastic agent and the free anterior capsule was removed. The remaining steps of Phaco were then performed, as well as the implantation of the IOL into the patient's capsular bag. Preoperative pupillary dilation was carried out during a traditional Phaco with IOLI. After topical anesthesia and standard disinfection, a 2.4-mm transparent corneal incision was made, through which viscoelastic agents were injected into the anterior chamber. Subsequently, a continuous curvilinear capsulorhexis with a diameter between 5.5 and 6.0 mm was performed. The lens nucleus and cortex were aspirated using the Alcon Centurion Phaco system, and the IOL was implanted into the capsular bag. The viscoelastic agent was then eliminated, and a watertight incision was made. The conjunctival sac was coated with tobramycin dexamethasone eye ointment after the IOP was checked, and the operated eye was bandaged. Surgical complications were recorded. The same ophthalmologist with significant surgical experience performed both procedures.

IOLs: The type of IOLs was selected based on the ocular conditions of patients, the need for postoperative lens removal, and their economic conditions. IOLs were classified as multifocal (including trifocal, bifocal, or extended range of vision [ERV] IOLs), astigmatic (including bifocal or monofocal combined astigmatism-corrected IOLs), and monofocal (including C-Loop, four-loop or three-piece IOLs). The IOLP was measured using the IOL-Master 500 (9 eyes in 6 early cases) or the OA2000, and the calculation formula was selected based on the patient's eye axis and post-refractive corneal refractive power. Barrett TrueK, Barrett Universal II, Shammas-PL, Haigis-L, and SRK-T were among the reference calculation formula used.

Statistical methods: The SPSS software package (version 11) was used to analyze the data, and the paired Student two-tailed t-test was utilized to evaluate differences between preoperative and postoperative values. Measurement data and count data are displayed as mean value ± standard deviation (SD) and percentages (%), respectively. *P* values of 0.05 or lower were deemed statistically significant.

Results

This retrospective study examined the medical records of 23 cases (38 eyes) of cataract patients who underwent refractive surgery, including 15 cases (24 eyes) of LASIK, 1 case (1 eye) of PRK after LASIK, 5 cases (10 eyes) of RK, and 2 cases (3 eyes) of ICL implantation. The patients had a mean age of (50.3±7.2) years old (range: 39-65) and a mean course of disease of (4.9±2.5) years, with diabetes mellitus and hypertension found in 11 and 8 cases, respectively. **Table 1** displays the basic preoperative data for these eyes. The mean preoperative visual acuity (logMAR) of the 24 eyes with LASIK was (0.9±0.7) (preoperative), while the values for LASIK with PRK (1 eye), RK (10 eyes), and ICL (3 eyes) were 0.5, (0.8±1.1), and (0.4±0.2), respectively. The mean IOPs (mmHg) of the 24 eyes with LASIK was (11.5±2.8) (preoperative), while the values for LASIK with PRK (1 eye), RK (10 eyes), and ICL (3 eyes) were 8, (17.5±2.3), and (13.3±2.5), respectively. The four groups showed no significant differences in gender, mean preoperative VA, and axial length (all P>0.05) while obvious differences in age, preoperative IOP, and corneal curvature (all P<0.001).

In terms of surgical modalities for cataracts, 15 eyes received FLACS with IOLI, indicating that more than one-third of patients chose femtosecond lasers when their eye conditions allowed. In terms of IOLs, there were 11 eyes with trifocal IOLs, 4 eyes with ERV IOLs, and 2 eyes with a bifocal combined astigmatism-corrected IOL. There were 5 eyes with astigmatism-corrected IOLs (original operation methods: LASIK in 3 eyes and RK in 2 eyes), indicating that some patients had corneal astigmatism even after years of corneal refractive surgery (CRS). Patients who selected FLACS with IOLI had a satisfactory postoperative effect and experienced no complications during the surgical procedure. In this study, 6 patients (11 eyes) chose trifocal IOLs (5 after LASIK and 1 after ICL implantation), 3 patients (4 eyes) chose ERV IOLs (2 after LASIK and 1 after RK), and 4 patients (5 eyes) chose astigmatism-corrected IOLs, all with high postoperative satisfaction. The IOLP for patients who had undergone LASIK or PRK was calculated primarily using the Barrett TrueK's formula, which was based on the findings of Haigis-L, SRK-T, and Shammas-PL. For those with an eye axis greater than or equal to 27 mm, the eye axis was corrected using the correction formula and then substituted into the calculation formula. In terms of IOLP reservation, the negative number closest to 0 was used for multifocal IOLs; based on each patient's daily eye habits, experience, and references [16], -1.00--1.50D was reserved for dominant eyes or eye axes under 27 mm, and -1.50--2.00D was reserved for non-dominant eyes or eye axes over 27 mm for monofocal IOLs. The selection and calculation of cataract surgery methods and IOLs are displayed in **Table 2**. In addition, the results (**Table 2**) show a significant difference in IOL degree (P<0.001) among the four groups and no significant difference in reserved degree (P>0.05).

IOLs were implanted intraoperatively into the capsular bag, with the exception of one patient who had an IOL implanted in the ciliary sulcus due to lens subluxation prior to LASIK. In one patient who underwent RK, there was a small dehiscence of the radial incision in the original cornea, which was sutured intraoperatively. There was no posterior capsule rupture or other intraoperative complications. On the first postoperative day, patients' VA was significantly improved compared to that before surgery, rising from (0.9±0.7) to (0.1±0.2) in patients undergoing LASIK, 0.5 to 0.2 in those receiving LASIK with PRK, and (0.8±1.1) to (0.1±0.1) in patients undergoing RK (t=5.406, P=0.0001), with the postoperative D close to the preoperative reserved D and high postoperative satisfaction. The majority of patients were satisfied with their postoperative VA. In comparison to other surgeries, ICL removal with Phaco and IOLI resulted in a slightly longer operation time, milder postoperative corneal edema, and slightly worse VA, which changed from (0.4±0.2) of preoperative VA to (0.3±0.04) postoperative VA in ICL on the first day after the operation due to the additional steps of ICL removal; the vision on the first day after the operation was satisfactory for the others. **Table 3** shows the postoperative condition and complications. Statistical analysis showed that the postoperative VA and spherical equivalent refractive error (D) were not significantly different among the four groups (P>0.05), nor was there any obvious difference in the complication rate between LASIK and the other three groups (P>0.05); however, significant differences were determined in postoperative IOP among four groups (P<0.001).

Discussion

Selection of surgical methods and precautions during operation

The corneal scar after RK surgery is reported to affect the surgical field of vision and increases surgical difficulty [8]. The scar from radial corneal incision should be avoided as much as possible during cataract surgery due to poor corneal healing or scar healing after RK [9]. According to some studies, even with 8 or 12 radial corneal incisions following RK, a transparent corneal incision can be made between 2 incisions without causing incision dehiscence. The transparent corneal incision of the cataract may result in corneal dehiscence if the corneal

Table 2. Selection and calculation of cataract surgery methods and IOLs

Refractive surgery methods	Cataract surgery methods	IOL type	IOL calculation formula	IOL degree (D)	Reserved degree (D)
LASIK (24 eyes)	F+P+I: 15 (62.5) eyes P+I: 9 (37.5) eyes	Aspheric single-focus: 9 (37.5) eyes Diffuse Correction Type: 3 (12.5) eyes Continuous Visual Range: 2 (8.3) eyes Triple Focus: 10 (41.7) eyes	Barrett TrueK Haigis-L SRK-T Shammas-PL	18.7±2.9	-0.6±0.6
LASIK+PRK (1 eye)	P+I: 1 (100.0) eye	Aspheric single-focus: 1 (100.0) eye	Barrett TrueK	23	0.36
RK (10 eyes)	P+I: 9 (90.0) eyes P+I+tension ring: 1 (10.0) eye	Aspheric single-focus: 6 (60.0) eyes Radiolucent correction type: 2 (20.0) eyes Continuous Visual Range: 2 (20.0) eyes	Barrett TrueK	24.0±2.3	-0.6±0.6
ICL (3 eyes)	ICL extraction+P+I: 3 (100.0) eyes	Astigmatism bifocal: 2 (66.7) eye Triple Focus: 1 (33.3) eye	Barrett UII	11.2±5.3	-1.0±1.2
F value	-	-	-	16.64	1.10
P value	-	-	-	<0.001	0.36

Note: LASIK, laser in situ keratomileusis; PRK, photorefractive keratectomy; RK, radial keratotomy; ICL, implantable collamer lens; IOL, intraocular lens.

Table 3. Postoperative condition and complications

Refractive surgery methods	Postoperative vision (logMAR)	Postoperative IOP (mmHg)	Postoperative spherical equivalent refractive error (D)	Complications
LASIK (24 eyes)	0.1±0.2	13.3±3.2	-0.5±0.8	1 case of lens subluxation with IOL ciliary sulcus fixation
LASIK+PRK (1 eye)	0.2	9	-0.25	In one case, the original intraoperative corneal radial incision was split and required suturing; in one case, hyperopic drift and diurnal fluctuations in visual acuity occurred early after surgery
RK (10 eyes)	0.1±0.1	18.4±3.4	-0.5±0.4	
ICL (3 eyes)	0.3±0.04	17.7±3.5	-1.0±1.1	
Chi-square/F value	1.31	7.54	0.47	1.55
P value	0.29	<0.001	0.70	0.21

Note: LASIK, laser in situ keratomileusis; PRK, photorefractive keratectomy; RK, radial keratotomy; ICL, implantable collamer lens; IOP, intraocular pressure.

radial incision is up to 16 cuts, so a scleral tunnel incision should be chosen instead because the distance between the corneal radial incisions is so small [10]. However, intraoperative changes in anterior chamber pressure can still lead to corneal scar dehiscence. If the dehiscence is small, with minimal water leakage, the operation can still be successfully performed without suturing the dehiscence, while having no discernible effect on the postoperative vision. The need to fill the anterior chamber with a viscoelastic agent, to suture the tear, or to reselect the incision to complete the procedure, on the other hand, is indicated by the large dehiscence and significant leakage of water during the procedure. In this instance, corneal edema or astigmatism resulting from the suture has an impact on the postoperative VA. In this study, one patient had 12 radial corneal incisions following RK surgery, which is consistent with previous findings [10]. The transparent corneal incision for cataract surgery was made at the widest angular margin that existed between two RK scars. The 2.4 mm main incision was still located at a significant distance from the RK corneal scars on both sides. However, as the operation progressed and the number of intraocular operations increased, the main incision became progressively edematous and a dehiscence developed at the RK corneal scar, making subsequent surgical procedures challenging. Finally, the corneal scar tear required one stitch to complete the procedure. To prevent corneal scar dehiscence in patients who have undergone RK surgery, a scleral tunnel incision is recommended as the primary incision for cataract surgery.

The variation coefficient and hexagonal cell ratio of corneal endothelial cells (CECs) tend to be abnormal in cataract patients with high myopia [11]. RK surgery and deep PRK may also harm CECs [12], and those undergoing ICL implantation are more likely to experience CEC loss. Therefore, attention should be paid to the aforementioned parameters prior to cataract surgery, the protection of CECs during the procedure, and the quantity and quality of corneal endothelium following cataract surgery.

Infusion misdirection is common during intraoperative perfusion in cataract surgery in highly myopic patients due to increased axial length, enlarged eyeballs, deep anterior chambers, relaxed or even partially amputated suspensory ligaments, and vitreous liquefaction. To reduce posterior chamber pressure, mannitol should be quickly dripped when necessary. Intraoperative perfusion pressure is recommended to be adjusted according to the actual situation. The perfusion pressure should be kept as constant as possible throughout the procedure to prevent excessive variations that could cause the capsular bag to rise and fall, putting additional pressure on the already relaxed suspensory ligament. If the suspensory ligament is relaxed or partially ruptured during surgery, a capsular tension ring can be implanted to relieve pressure on the ligament and keep the IOL in place.

ICL surgery is gaining acceptance among patients, particularly those with severe myopia. The optimal intraocular lens position of the fourth generation ICLs is on the ciliary process [13]. However, the majority of ICL loops are located on the suspensory ligament rather than the ciliary process, primarily due to the distinct morphology or degree of development of the ciliary process [8]. The low arch height not only causes continuous mechanical stimulation to the suspensory ligament that causes further relaxation or calcification of the suspensory ligament, but also easily leads to subcapsular opacification of the anterior lens, known as a cataract. Most of the high myopia-related cataracts are nuclear cataracts, and with the clinical application of ICL surgery, cataracts after refractive surgery may also be subcapsular opacification. One of the patients in this study underwent cataract surgery after developing anterior subcapsular opacity just a year after refractive surgery. This is consistent with earlier studies, which show that a visually significant cataract is uncommon in the first few years following ICL implantation [14].

Many cataract patients who have undergone refractive surgery hope to benefit from the use of a femtosecond laser in cataract surgery. FLACS is not an absolute contraindication to refractive surgery [15], and the feasibility of this procedure is primarily determined by the patient's corneal and intraocular conditions. Femtosecond laser after RK was not recommended because the corneal scar was too deep to assess the degree of corneal scar healing. In this study, 9 patients (15 eyes) chose to receive FLACS with IOLI 12-23 years after LASIK, and the corneal flap healed well in these patients. They chose FLACS with IOLI after careful consideration as they desired a more accurate surgical method. Because the cornea of patients after LASIK was relatively flat (below 42D), the PI model corresponding to femtosecond laser should be selected for more stable corneal binding. The remaining steps were similar to the conventional Phaco with IOLI procedure, and no corneal flap dislocation or separation occurred during the procedure. To prevent epithelial implantation, the corneal flap must be washed and reset between layers after cataract surgery if it is found to be misaligned [1]. In this study, patients who underwent FLACS with IOLI experienced no intraoperative complications and satisfactory postoperative outcomes. In a previous study, the FLACS group was shown to have fewer complications than the conventional group; however, in this study, no complications were observed in patients who chose FLACS with IOLI [16]. It has been reported that when using a femtosecond laser to perform cataract surgery after an ICL procedure, the laser device may mistake the ICL for its lens when scanning after stabilizing the eyeball, necessitating manual adjustment [17]. The air bubbles produced during the anterior capsule's cutting accumulate under the ICL after laser emission, affecting both the femtosecond laser's ability to cut the lens and the anterior capsule [18, 19]. And, if the resulting bubbles accumulate excessively and are unable to enter the anterior chamber due to the ICL obstruction, they can only be pushed backwards, which may damage the suspensory ligament. Currently, the use of femtosecond lasers in cataract surgery following refractive surgery is limited, and the safety of their application in such patients requires additional evidence. In order to avoid the risks associated with the formation of air bubbles from femtosecond lasers, it may be considered to use femtosecond lasers only to correct corneal astigmatism in cataract patients following ICL surgery.

Selection of IOLs

Corneal surgery for myopia involves reducing the thickness of the central cornea within a certain range in order to alter the corneal refractive power in this area and thus correct myopia. Following central corneal cutting, the thickness is reduced and the curvature becomes flat, changing the ratio of the curvature of the anterior and posterior corneal surfaces and increasing higher-order aberration, which influences postoperative visual quality to some extent [8]. However, the optical principle of multifocal IOLs, which are widely used in cataract surgery, may cause some optical interference [20]. As a result, doctors are cautious when selecting multifocal or astigmatic IOLs for cataract patients following CRS. As for as cataract patients after ICL implantation are concerned, the following must be considered as the majority of patients who choose this surgical modality are highly myopic (currently, the majority of patients who choose ICL implantation have moderate or low myopia): 1) whether a multifocal IOL with adequate power is available; 2) whether the suspensory ligament function of the patient with high myopia is intact and capable of maintaining and stabilizing the effective position of the multifocal or astigmatic IOL in the capsular bag; 3) whether there is an inflammatory reaction or adhesion between the implanted ICL and the intra-ocular tissues, and whether removal will damage the intra-ocular tissues or cause new corneal astigmatism. High postoperative satisfaction was reported by 6 patients (9 eyes) who chose trifocal IOLs (5 after LASIK and 1 after ICL implantation), 3 patients (4 eyes) who chose ERV IOLs (2 after LASIK and 1 after RK), and 4 patients (5 eyes) who chose astigmatism-corrected IOLs (3 after LASIK and 1 after RK).

Concerning IOLP, the calculation in cataract patients after CRS has always been problematic and can be divided into medical and non-medical history approaches [21]. It is widely assumed that the medical history method is more accurate because it takes into account the patient's refractive state prior to refractive surgery. In clinical work, however, it is difficult to locate medical records because patients' CRS was conducted more than or equal to two decades ago. In addition, this study found that corneal morphology may alter in the decades following CRS, resulting in the development of new astigmatism or D. Therefore, there will be errors if the data before refractive surgery is used for calculation. The current corneal curvature is calculated using the non-medical history rule. However, as part of the cornea's central surface was cut during refractive surgery, the ratio of anterior and posterior corneal surface curvatures has changed significantly. And due to the inability of the conventional calculation formula to accurately reflect the true corneal curvature of the entire cornea, the IOLP calculation is subject to significant errors [8]. There are emerging formulas for the calculation of D in patients with high myopia and cataract IOLP in post-CRS patients as a result of the development of the calculation formula [22]. In this study, Barrett TrueK's formula was used to calculate IOLP for patients undergoing LASIK and PRK, with reference to the Haigis-L, SRK-T, and Shammas-PL results. The eye axis was corrected using the correction formula if it was greater than 27 mm and then substituted into the formula for calculation. For multifocal IOLs, the negative number closest to 0 was used for IOLP reservation, while for monofocal IOLs, a range of -1.00--1.50D was reserved for the dominant eye or eye axis ≤27 mm, and a range of -1.50--2.00D was reserved for the non-dominant eye or eye axis >27 mm, taking into account each patient's daily eye habits and experience and references [23]. The majority of patients were satisfied with their postoperative VA.

Postoperative recovery

It is critical to assess refractive status as soon as possible following cataract surgery [8]. The presence of obvious postoperative refractive error indicates an incorrect IOLP. In this case, the IOL should be replaced as soon as possible, a piggyback IOL should be implanted, or CRS should be used to re-correct the residual power. In this study, the power selected by comparing various IOLP calculation formula was essentially consistent with the preoperative design, with high postoperative satisfaction and no apparent refractive accident. Due to the deep corneal incision and cicatricle healing associated with RK surgery, the early corneal tension may decrease further after cataract surgery. If the IOP is high at this time, the peripheral corneal scar will be further stretched and expanded, flattening the central cornea and possibly resulting in hyperopia drift in the early postoperative period [24]. The curvature of the weak cornea may be affected in some way, with the potential for myopia drift in the early postoperative period, if the cornea is thin after LASIK and the IOP is high after cataract surgery. Prior to surgery, patients must be informed of the aforementioned circumstances. In this study, one patient developed hyperopia drift early after surgery, which can be explained by the above information. So the question arises of how to distinguish whether it is a refractive error caused by a calculation error in D, or early postoperative hyperopia drift, or myopia drift? It can be determined by corneal curvature, corneal edema, and IOP before and after surgery.

Transient IOP is a common complication following cataract surgery. Patients with high myopia are at an increased risk of postoperative intraocular hypertension due to trabecular meshwork insufficiency or difficulty in the cleaning of viscoelastic agents [25]. However, in post-CRS patients, the IOP measured by a non-contact tonometer is less accurate and lower than the true IOP due to changes in corneal tension caused by corneal cutting. Actually, it is more subtle and challenging to detect when IOP increases after cataract surgery; when the IOP is found to be higher than usual, the actual IOP is frequently higher [26]. Therefore, clinicians need to be aware of this phenomenon.

After cataract surgery, RK patients may experience circadian fluctuations in VA, which means that their vision is at its best when they wake up in the morning, gradually deteriorates over time, and is at its worst at night. The following morning, after a night's rest, their vision is recovered [27]. This phenomenon can occur after RK and last for several years or even a decade [28]. It has also been reported that this phenomenon did not occur after RK but after cataract surgery [29]. It was also noted in one patient undergoing RK surgery in this study. After the RK procedure, the patient did not experience circadian fluctuations in VA for 29 years, but developed them after cataract surgery. This phenomenon has not been observed in patients who have undergone other types of refractive surgery, possibly due to fluctuations in IOP or changes in corneal tension. The condition can be monitored without treatment in those whose circadian VA fluctuations have minimal effects on their daily lives; otherwise, corneal cross-linking surgery [30] or a Bowman layer transplant may be an option [31].

This study included a unique case in which a cataract patient undergoing binocular RK had a bifocal IOL implanted in the first eye and an ERV IOL implanted in the second eye two weeks later. The patient insisted on having the first eye replaced with an ERV IOL after noticing that it provided better visual quality than the bifocal IOL implanted in the first eye. However, after the IOL was replaced, the patient continued to experience visual disturbances, complaining of better daytime vision and worse night vision. It is believed that patients undergoing cataract surgery following refractive surgery should exercise caution in selecting bifocal, trifocal, or astigmatism-corrected IOLs. In addition to a thorough evaluation of the cornea, suspensory ligaments, fundus, and other conditions, it is essential to inform the patient of the possibility of visual defects and refractive errors following refractive surgery to increase postoperative satisfaction. Case studies demonstrate that ERV IOLs are more accommodating than multifocal IOLs for patients with corneal higher-order aberrations and irregular astigmatism following RK.

Patients who choose refractive surgery when they are young have a strong desire to disengage the lens. The cornea, suspensory ligaments, fundus, etc., as well as the need for effective preoperative communication, all play a role in determining lens removal following cataract surgery. High myopic retinopathy, which is more common in patients with high myopia, can progress even after refractive and cataract surgery. Such patients should be advised to have their fundus examined regularly.

Conclusion

In conclusion, patients who have undergone refractive surgery for cataracts can choose FLACS with IOLI or traditional Phaco with IOLI. Multifocal, ERV or trifocal IOLs can be selected for postoperative lens removal, depending on the patient's eye condition, living needs, and financial circumstances. Curative outcomes that meet patient expectations require familiarity with the specifics of their condition, expertise in pre- and post-operative diagnosis and treatment, accuracy in IOLP calculations, open discussions with patients regarding their expectations for surgery, and a feasible surgical plan. As a retrospective analysis, this study is limited by some incomplete postoperative data. The visual acuity of patients undergoing cataract surgery following refractive surgery could be more thoroughly assessed if the postoperative corneal topography and contrast sensitivity examinations could be enhanced according to the time points. The therapeutic effect of cataract surgery for patients who have undergone refractive surgery will be continuously improved with the introduction of new IOLP calculation formulas, novel intraoperative technical devices, and new-generation IOLs.

Acknowledgements

2020 Shenzhen Aier Eye Hospital Scientific Research Project In-Hospital Project (Elite) Project Number: SZAE2020B01.

Disclosure of conflict of interest

None.

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