Journal of Ophthalmology

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Lead Guest Editor: Andreas Borkenstein
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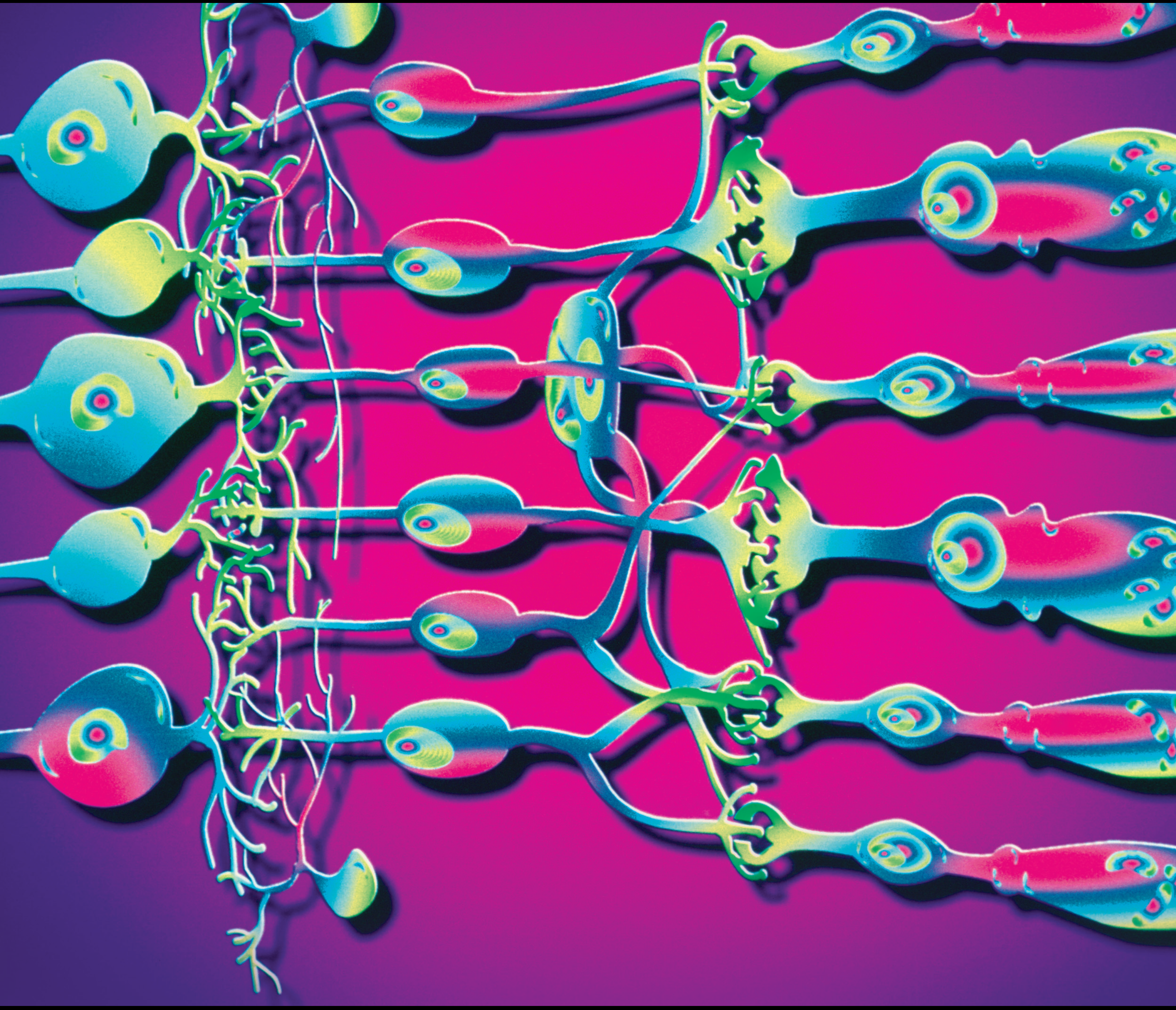

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Contents

Hindawi
Journal of Ophthalmology
Volume 2022, Article ID 4810103, 8 pages
https://doi.org/10.1155/2022/4810103

Research Article

Two-Year Follow-Up of Clinical Efficacy of Femtosecond Laser, Modified Capsular Tension Ring, and Iris Hook-Assisted Surgical Treatment of Lens Subluxation in Patients with Elevated Intraocular Pressure

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Received 20 January 2022; Accepted 19 April 2022; Published 9 May 2022

Academic Editor: Alessandro Meduri

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Purpose. To evaluate the outcomes of femtosecond laser, modified capsular tension ring, and iris hook-assisted surgical treatment of lens subluxation in patients with elevated intraocular pressure (IOP). *Methods*. Fifteen patients with lens subluxation and elevated IOP were enrolled in this study. All patients underwent femtosecond-laser-assisted cataract surgery/phacoemulsification/intraocular lens implantation/modified capsular tension ring (MCTR) implantation with iris hook assistance. Uncorrected visual acuity (UCVA), best corrected visual acuity (BCVA), IOP, number of glaucoma medication complications, endothelial cell density (ECD), and tilt of the lens were recorded before and after surgery. All patients were observed for 24 months postoperatively. *Results*. UCVA and BCVA increased significantly at 1 month, 6 months, 12 months, and 24 months, compared with preoperative UCVA and BCVA ($P < 0.001$). IOP significantly decreased at 1 month, 3 months, 6 months, 12 months, and 24 months, compared with preoperative IOP ($P < 0.001$). 3 patients received glaucoma medications to control IOP after surgery. All medications were discontinued at 3 months postoperatively. Conjunctival redness or hemorrhage was observed in 11 patients (73.3%); transient corneal edema was observed in 3 patients (20.0%); and posterior capsule opacification occurred in 1 patient (6.67%). The ECD and tilt of the lens are within an acceptable range. *Conclusion*. The combined use of a femtosecond laser, MCTR, and iris hooks is an effective and safe method for treating patients with lens subluxation and elevated IOP.

1. Introduction

Lens subluxation is a type of ectopia lentis that presents as a partial dislocation of the lens. It is a common eye disease that could be congenital or acquired. Congenital diseases such as Marfan syndrome are considered to cause altered fibrillin microfibrils which will lead to abnormalities of zonular fibers and lens capsule [1]. Congenital aniridia is a rare bilateral pan ocular disorder and is associated with lens subluxation [2]. The acquired lens subluxation can be traumatic and spontaneous. Blunt trauma is the most common cause. Spontaneous lens subluxation secondary to other ocular diseases such as glaucoma, high myopia, retinal detachment, and pseudoexfoliation syndrome. Postcataract surgery lens subluxation is also a common issue for clinical management. Occult lens subluxation could also be secondary to laser peripheral iridotomy [3]. The major changes in lens subluxation of different causes are typical: partial tearing or loosening of zonular ligaments and dislocation of the lens. Lens subluxation can cause impaired vision and even lead to dangerous complications if left unt\]reated. The dislocated lens becomes spherical because of its own elasticity, thereby increasing its anteroposterior diameter which will lead to pupillary block, shallow anterior chamber, and anterior chamber angle closure. Acquired lens subluxation can also be accompanied by vitreous prolapse. Therefore, elevated IOP is common and critical in patients with lens subluxation [4, 5]. Clinical treatments for lens subluxation are complex. Patients who received inappropriate or delayed treatments may exhibit uncontrollable elevated IOP and require additional surgeries. With the advent of extracapsular cataract extraction and intraocular lenses (IOLs), intracapsular cataract extraction was replaced during lens subluxation treatment [6]. Practical surgical considerations should include the removal of the lens and its capsule as well as the preservation of IOL stability. The challenges of lens subluxation treatment mainly involve difficulty with continuous curvilinear capsulorhexis (CCC), as well as poor lens stability, vitreous prolapse, and serious complications [7].

Recent advances in surgical techniques allow for combined application of femtosecond-laser-assisted cataract surgery (FLACS)/phacoemulsification (PE)/IOL implantation/modified capsular tension ring (MCTR) implantation surgery with iris hook assistance that greatly improved the surgical safety and outcomes of lens subluxation. The application of femtosecond laser technology leads to less damage, facilitates CCC, improves accuracy, and aids in achieving good visual quality [8, 9]. Iris hooks greatly improve the stability of the capsular bag, which aids in PE and IOL implantation [10]. MCTR implantation improves the stability of the capsular bag [11]. By combining these three techniques, the operation is safe and IOP can be controlled in an optimal manner. In this retrospective study, we evaluated the outcomes of the combined application of these three techniques in treating patients with lens subluxation and elevated IOP and provided guidance for future clinical management.

2. Materials and Methods

This comparative, retrospective, cohort study included patients with lens subluxation and elevated IOP from November 2018 to May 2021. Informed consent was obtained from all patients recruited prior to the study. Patient-specific surgical procedures were determined by the treating physicians and were performed according to the standard-of-care of our hospital. Deidentified medical records were screened and extracted between 12th May 2021 and 16th May 2021. This study was approved by the clinical medical ethics committee of Xiangya Hospital, Central South University, and adhered to the tenets of the Declaration of Helsinki.

All 15 patients recruited had elevated IOP; 10 of them had traumatic lens subluxation and 5 of them had idiopathic lens subluxation. Detailed demographic information is provided in Table 1. All patients underwent FLACS/PE/IOL implantation/MCTR implantation surgery with iris hook assistance. 6 patients exhibited vitreous prolapse in the anterior chamber, which required anterior vitrectomy. An astigmatic keratotomy was performed in 1 patient to correct astigmatism. All surgeries were performed by a single skilled surgeon (JJ). Patient characteristics were recorded as follows: UCVA BCVA, IOP before the surgery and 1 day, 1 month, 3 months, 6 months, 12 months, and 24 months after surgery; use of antiglaucoma treatment before and after surgery; postoperative complications, ECD, and tilt of the lens; type of capsular tension device used and type of IOL implanted.

2.1. Surgical Technique. Anterior angle, degree of lens subluxation, and pupil status were evaluated carefully before the surgery. Topical levofloxacin (Cravit; Santen, Japan) was applied to the eye scheduled for surgery, four times a day for 3 days before surgery. Tropicamide phenylephrine (Cravit; Santen, Japan) was used to dilate pupils 30 minutes before surgery. The patient's head position was fixed and ocular surface was anaesthetised with oxybuprocaine hydrochloride eye drops (Cravit; Santen, Japan). FLACS was performed using the Victus platform (Bausch + Lomb, Rochester, NY, USA) with conventional femtosecond laser settings. Femtosecond laser-assisted astigmatic keratotomy was performed in 1 patient to correct astigmatism. For FLACS, a 5.0 mm-diameter capsulotomy with pupil centration was performed, following a concentric cylinder and a chop (sextants cut) pattern for lens fragmentation. A 2.8 mm transparent corneal incision and a corneal side incision were created with a disposable keratome. The anterior capsule was then removed, and Viscoelastic (Bausch + Lomb, Rochester, NY, USA) was injected into the anterior chamber. A 15° knife was used to make five limbal incisions at intervals of approximately 75°. Five iris hooks were attached to the edge of the capsule through the incisions, which allowed fixation and centering of the lens. Patients who exhibited intraoperative vitreous prolapse in the anterior chamber underwent anterior vitrectomy.

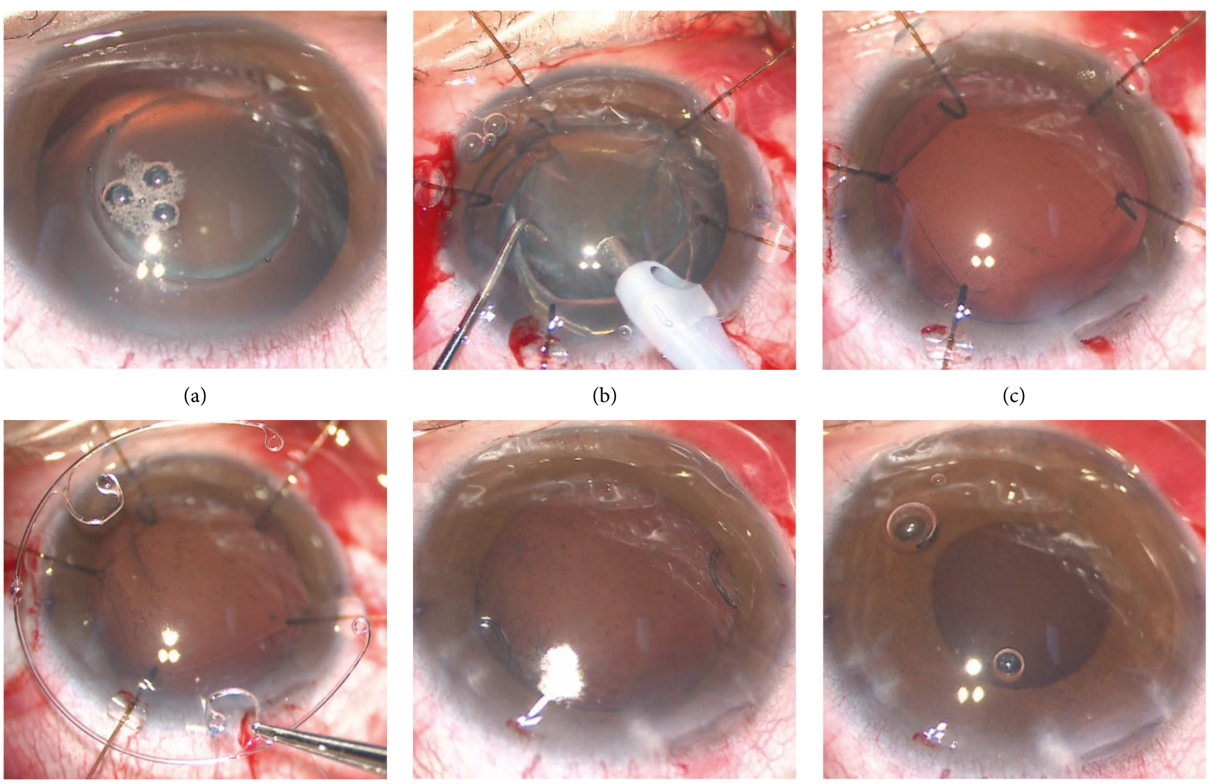
For the PE procedure, we used Stellaris PC (vitreous cutter; Bausch + Lomb, Rochester, NY, USA) and Centurion® Vision System (Alcon Laboratories, Inc., Fort Worth, TX, USA) for all patients and kept system settings consistent. Sufficient hydrodissection and hydrodelineation were carefully performed to reduce the pressure on zonular ligaments during the PE process. Without rotation of the nucleus, the cortex was separated along femtosecond cleavage planes and aspirated with the PE probe. A chopper was applied to resist influences caused by negative pressure on the capsular bag. Low flow, low perfusion pressure, low negative pressure, and low ultrasonic energy were kept during PE (Figure 1).

Polymethylmethacrylate MCTR (Morcher GmbH, Stuttgart, Germany) was implanted in the capsular bag, fixation hooks were attached to a 9–0 polypropylene suture (Ethicon, Somerville, NJ, USA) and knotted in the prescleral tunnel 2.0 mm behind the limbus (Figure 2). The IOL (Tecnis ZCB00 or Rayner920) was implanted in the capsular bag using a syringe, iris hooks were then removed, and the anterior chamber viscoelastic agent was aspirated. Hydration was then performed to seal the clear corneal incisions.

2.2. Postoperative Protocol. The following topical medication regimen was prescribed: levofloxacin eye drops and prednisolone acetate (Allergan, Irvine, CA, USA) eye drops, 4

Table 1: Demographic and clinical characteristics of eyes in this study.

Patient	Sex	Follow- up (M)	Age (Y)	Eye	Etiology	Clock hours	Vitreous prolapse	IOL	Surgical procedure
1	M	24	50–54	OS	Trauma	5	–	ZCB00	FLACS/PE/IOL/MCTR
2	M	24	35–40	OD	Trauma	6	+	Rayner920	FLACS/PE/IOL/MCTR/Vitrectomy
3	F	24	40–44	OD	Trauma	5	–	ZCB00	FLACS/PE/IOL/MCTR
4	M	24	55–60	OD	Idiopathic	5	–	Rayner920	FLACS/PE/IOL/MCTR
5	F	24	55–60	OS	Idiopathic	6	–	Rayner920	FLACS/PE/IOL/MCTR
6	M	24	60–64	OD	Trauma	6	+	ZCB00	FLACS/PE/IOL/MCTR/Vitrectomy
7	M	24	65–69	OD	Trauma	5	–	ZCB00	FLACS/PE/IOL/MCTR
8	M	24	50–54	OD	Idiopathic	5	+	ZXR00	AK/FLACS/PE/IOL/MCTR/ Vitrectomy
9	F	24	55–60	OD	Trauma	5	+	Rayner920	FLACS/PE/IOL/MCTR/Vitrectomy
10	M	24	45–50	OS	Trauma	5	–	Rayner920	FLACS/PE/IOL/MCTR
11	M	24	45–50	OS	Trauma	5	–	ZCB00	FLACS/PE/IOL/MCTR
12	M	24	40–44	OD	Trauma	6	+	ZCB00	FLACS/PE/IOL/MCTR/Vitrectomy
13	M	24	45–50	OS	Trauma	6	+	Rayner920	FLACS/PE/IOL/MCTR/Vitrectomy
14	F	24	55–60	OD	Idiopathic	5	–	ZCB00	FLACS/PE/IOL/MCTR
15	F	24	55–60	OD	Idiopathic	5	–	ZCB00	FLACS/PE/IOL/MCTR



(a) (b) (c)

(d) (e) (f)

Figure 1: (a) Capsulotomy by femtosecond laser centred on the capsular bag. (b, c) Five iris hooks were attached to the edge of the capsule through the incisions to ensure fixation and centering during the PE procedure. (d) The MCTR was implanted in the capsular bag. ((e), (f)) Iris hooks were removed, and the anterior chamber viscoelastic agent was aspirated. Hydration was performed to seal the clear corneal incisions.

times/day for 2 weeks; pranoprofen eye drops (Senju Pharmaceutical Ltd., Osaka, Japan), 4 times/day for 1 month. 2 patients were prescribed with Timolol (Wujing, Wuhan, China) for IOP control, 2 times/day for 3 months. Postoperative examinations and data collection were performed as mentioned in previous section.

2.3. Statistical Analysis. All data were analysed using PASW 18.0 (SPSS Inc., Chicago, IL, USA). Results are reported as the mean ± standard deviation. Paired t-test was used for repeat testing of UCVA, BCVA, IOP, and ECD in each patient. Differences were considered to be statistically significant when $P < 0.05$.

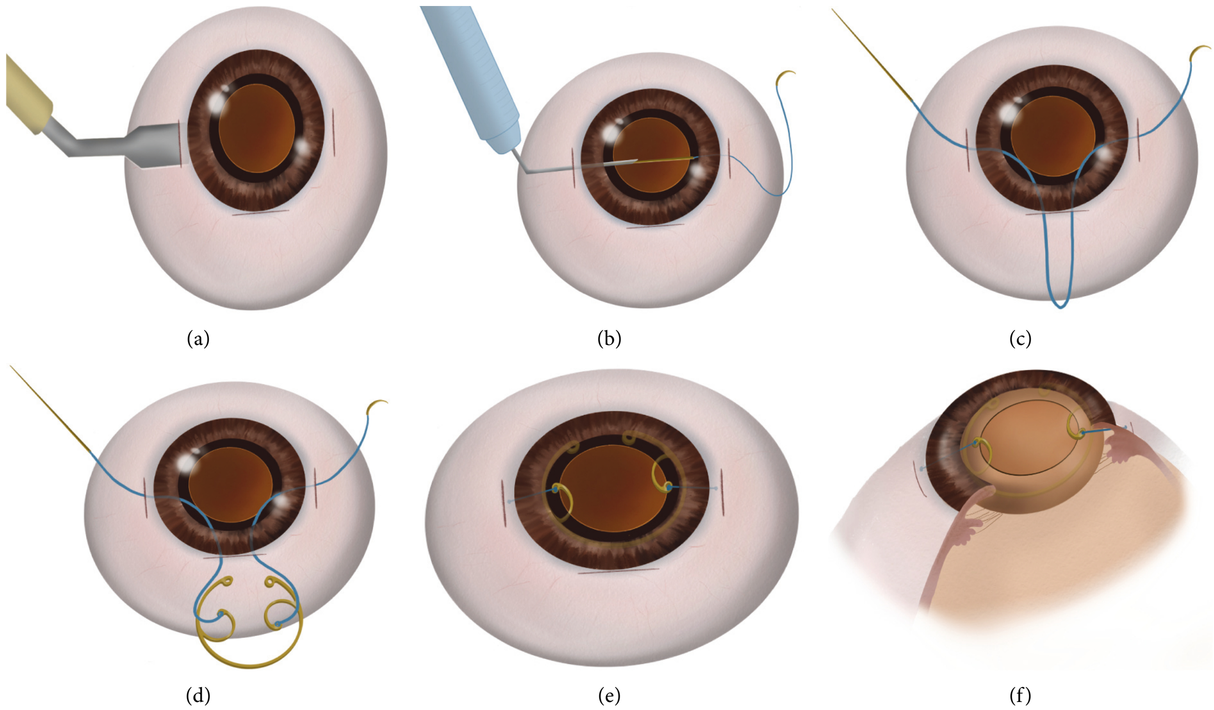


Figure 2: (a) Nasal and temporal scleral tunnels were made by a crescent knife at 2.0 mm behind the limbus. (b) A 9–0 polypropylene suture was threaded through scleral tunnels. (c) The suture was pulled out from the main incision carefully. (d) The suture was cut in half and attached to the fixation hooks of MCTR. (e, f) MCTR was implanted in the capsular bag, and the suture was knotted in the scleral tunnel.

3. Results

15 patients (15 eyes) with lens subluxation were recruited in this study. 10 patients exhibited traumatic lens subluxation and 5 patients exhibited idiopathic lens subluxation. All patients had elevated IOP. Detailed patient information is shown in Table 1. There were 10 male and 5 female, with an average age of 52.40 years (median: 53 years; range: 38–65 years). All patients were followed up for 24 months with one exception case that was lost to follow-up at 6 months. All patients underwent FLACS/PE/IOL implantation/MCTR implantation surgery. 6 of them underwent additional anterior vitrectomy due to vitreous prolapse in the anterior chamber (Table 1).

UCVA increased significantly at 1 month (0.22 ± 0.14, $P < 0.001$), 3 months (0.18 ± 0.11, $P < 0.001$), 6 months (0.16 ± 0.12, $P < 0.001$), 12 months (0.16 ± 0.11, $P < 0.001$), and 24 months (0.14 ± 0.10, $P < 0.001$) postoperatively, compared with their preoperative UCVA (1.06 ± 0.54). BCVA increased significantly at 1 month (0.10 ± 0.08, $P < 0.001$), 3 months (0.09 ± 0.09, $P < 0.001$), 6 months (0.06 ± 0.10, $P < 0.001$), 12 months (0.05 ± 0.10, $P < 0.001$), and 24 months (0.04 ± 0.09, $P < 0.001$) postoperatively, compared with preoperative BCVA (0.77 ± 0.54) (Table 2 and Figure 3).

IOP significantly decreased at 1 month (18.87 ± 4.03 mm·Hg, $P < 0.001$), 3 months (17.53 ± 3.09 mm·Hg, $P < 0.001$), 6 months (16.71 ± 2.70 mm·Hg, $P < 0.001$), 12 months (16.87 ± 2.75 mm·Hg, $P < 0.001$), and 24 months (17.33 ± 1.84 mm·Hg, $P < 0.001$) postoperatively, compared with preoperative IOP (30.13 ± 5.15 mm·Hg). 3 patients required postoperative glaucoma medications to control IOP and all medications were discontinued at 3 months after surgery. All patients required glaucoma medications to maintain IOP in the normal range before surgery. Combined application of timolol and brimonidine tartrate eye drops (Allergan) was prescribed for treating patients with IOP >30 mm·Hg, while timolol was used alone for IOP within 21–30 mm·Hg. Three patients required postoperative use of timolol to control IOP. At 3 months postoperatively, all patients exhibited optimal IOP control without any glaucoma medications (Table 3 and Figure 3).

Conjunctival redness or hemorrhage was observed in 11 patients (73.3%). Transient corneal edema was observed in 3 patients (20.0%) and posterior capsule opacification occurred in 1 patient (6.67%). Descemet's membrane detachment, lens material in vitreous, posterior capsule rupture, and iris damage were not observed in all 15 patients (Table 4).

Decreased ECD was observed in all 15 patients at 24 months (2182.67 ± 138.84) after surgery compared with preoperative ECD (2294.40 ± 142.84, $P < 0.001$) but the differences were within the normal range. Visual quality was assessed using OPD Scan III (Nidek Inc., Tokyo, Japan) at 24 months after surgery. The tilt of the lens (<1) is within an acceptable range, and there is no effect on vision acuity (Table 5 and Table 2).

Ultrasound biomicroscopy (UBM) prior to the surgery revealed subluxated lens and vitreous entering the anterior chamber whereas after the surgery, the IOL and MCTR were in correct positions (Figure 4).

Table 2: Postoperative UCVA and BCVA.

Patient	UCVA (logMAR)						BCVA (logMAR)					
	Preop	1 M	3 M	6 M	12 M	24 M	Preop	1 M	3 M	6 M	12 M	24 M
1	0.70	0.05	0.10	—	0.10	0.10	0.40	0.00	0.00	—	0.00	0.00
2	1.70	0.40	0.30	0.22	0.22	0.22	1.22	0.05	0.05	0.05	0.05	0.05
3	1.00	0.15	0.15	0.15	0.15	0.15	0.70	0.10	0.10	0.10	0.10	0.10
4	0.52	0.15	0.05	0.00	0.00	0.00	0.52	0.05	0.00	−0.08	−0.08	0.00
5	1.40	0.22	0.30	0.22	0.30	0.22	1.10	0.22	0.22	0.15	0.15	0.15
6	1.22	0.52	0.30	0.40	0.40	0.30	1.22	0.22	0.22	0.22	0.22	0.10
7	0.70	0.10	0.10	0.05	0.05	0.05	0.70	0.05	0.00	0.00	0.00	−0.08
8	2.30	0.30	0.22	0.22	0.22	0.15	2.30	0.10	0.00	−0.08	−0.08	-0.08
9	1.70	0.30	0.22	0.30	0.22	0.30	0.70	0.22	0.22	0.22	0.22	0.22
10	0.70	0.15	0.15	0.10	0.15	0.10	0.30	0.05	0.05	0.05	0.05	0.05

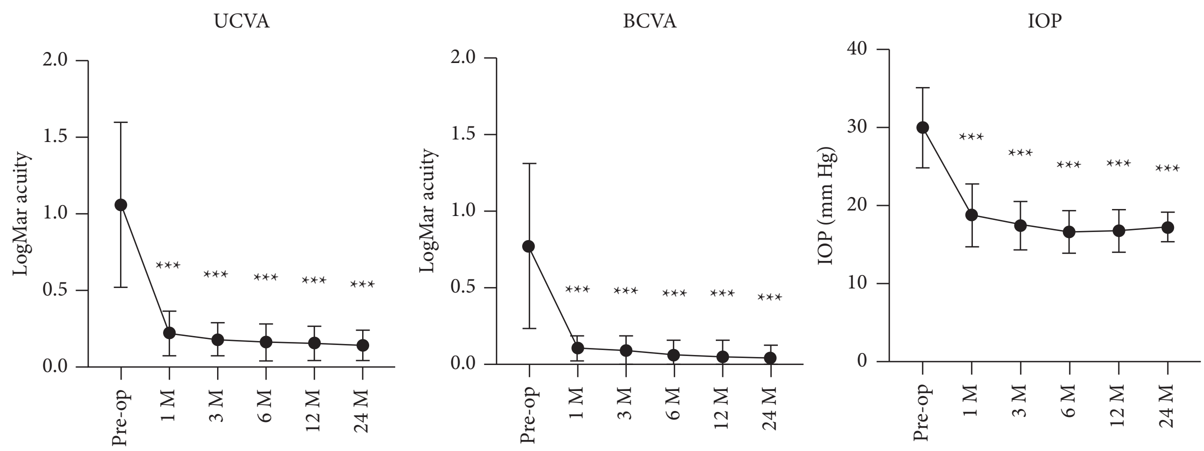


Figure 3: UCVA and BCVA significantly increased at 1 month, 3 months, 6 months, 12 months, and 24 months, compared with preoperative UCVA ($n = 15$, $^{***}P < 0.001$, $^{**}P < 0.005$). IOP significantly decreased at 1 month, 3 months, 6 months, 12 months, and 24 months, compared with preoperative IOP ($n = 15$, $^{***}P < 0.001$).

Table 3: Postoperative IOP and treatment results.

Patient	IOP (mmHg)						Postop antiglaucoma treatment
	Preop	1 M	3 M	6 M	12 M	24 M	
1	25	21	18	—	17	17	No
2	28	15	19	14	14	16	No
3	30	22	20	21	19	19	No
4	29	17	19	20	20	20	No
5	35	25	20	18	16	15	Yes
6	32	23	21	15	15	14	Yes
7	26	22	16	18	19	18	No
8	25	18	16	16	16	16	No
9	33	11	10	12	12	16	No
10	31	20	20	17	20	20	No
11	27	19	21	18	19	18	No
12	24	13	14	15	13	16	No
13	42	23	18	17	18	19	Yes
14	38	19	17	20	21	19	No
15	27	15	14	13	15	17	No

4. Discussion

A subluxated lens deviates from the visual axis, such that affected patients may exhibit astigmatism or monocular diplopia. During mydriatic examination, the equatorial portion of the lens and iris tremor is visible in the pupil area. In patients with lens subluxation, dislocation of the lens will lead to iris pushing forward, and frequently cause a shallow anterior chamber and elevated IOP. Vitreous prolapse and trabecular meshwork injury caused by trauma can also contribute to IOP elevation. Surgical treatment of lens subluxation is often considered difficult

Table 4: Postoperative complications.

Patient	Conjunctival redness or hemorrhage	Descemet's membrane detachment	Lens material in vitreous	Posterior capsule rupture	Transient corneal edema	Iris damage	Posterior capsule opacification
1	+	−	−	−	−	−	−
2	+	−	−	−	−	−	−
3	+	−	−	−	−	−	−
4	−	−	−	−	−	−	−
5	−	−	−	−	−	−	−
6	+	−	−	−	+	−	−
7	+	−	−	−	−	−	−
8	−	−	−	−	−	−	−
9	+	−	−	−	+	−	−
10	+	−	−	−	−	−	−
11	+	−	−	−	−	−	−
12	+	−	−	−	+	−	−
13	+	−	−	−	−	−	−
14	+	−	−	−	−	−	−
15	−	−	−	−	−	−	+

Table 5: Postoperative ECD and tilt of the lens.

Patient	ECD (Cells/mm^2)		IOL tilt
	Preop	Postop 24 m	Postop 24 m
1	2212	2101	0.774@89°
2	2398	2184	0.912@132°
3	2247	2082	1.003@233°
4	2301	2289	0.691@279°
5	2564	2437	0.847@23°
6	2218	2045	0.935@16°
7	2435	2341	0.787@63°
8	2497	2318	0.669@81°
9	2121	2058	0.894@168°
10	2230	2155	0.658@313°
11	2291	2201	0.992@245°
12	2206	2085	0.792@92°
13	2019	1916	0.805@58°
14	2387	2310	0.975@113°
15	2290	2218	0.881@328°

and has been considered as a contraindication for PE surgery. In the past, lens subluxation was treated by intracapsular cataract extraction, extracapsular cataract extraction with IOL suspension, or anterior chamber IOL implantation. These surgical methods, though proved to be effective, can be complicated in procedures. Along with prolonged operative times and large incisions, these methods may cause many complications, such as corneal endothelial decompensation and secondary glaucoma [6, 12, 13]. Notably, PE disturbs intraocular tissue, thereby enhancing the extent of lens dislocation and lens ligament damage. Due to a lack of adequate support, IOLs implanted are often eccentric, dislocated, or trapped by the pupil. These factors can also potentially reduce the safety of the surgical procedures.

The development of microsurgical techniques and equipment has improved our understanding of lens subluxation treatment. The combined application of FLACS, MCTR, and iris hook methods has been shown to greatly improve the safety and postoperative outcomes of lens subluxation treatment [14, 15]. The use of a preserved capsular bag can minimise disturbance to the vitreous body, while creating good conditions for IOL implantation. Furthermore, this technique can reduce the occurrence of complications such as retinal detachment and secondary glaucoma [16].

Regarding CCC, femtosecond laser-assisted in situ anterior lens capsule incision has several advantages including more accurate capsulotomy with a well-centered and an approximate ring shape. The process is also repeatable and predictable [17–19]. For patients with lens subluxation, femtosecond laser-assisted in situ anterior lens capsulotomy and laser cleavage can minimise surgical damage to the lens ligament. With this method, the lens capsular bag can be successfully protected in 90% of the eyes [8, 9, 20]. However, femtosecond laser treatment is not recommended for eyes with a large dislocation range and a capsulotomy area blocked by the iris. Our results indicate that the anterior vitreous has less influence on CCC, as shown in a prior study [21]. Notably, the IOP could be elevated due to the docking

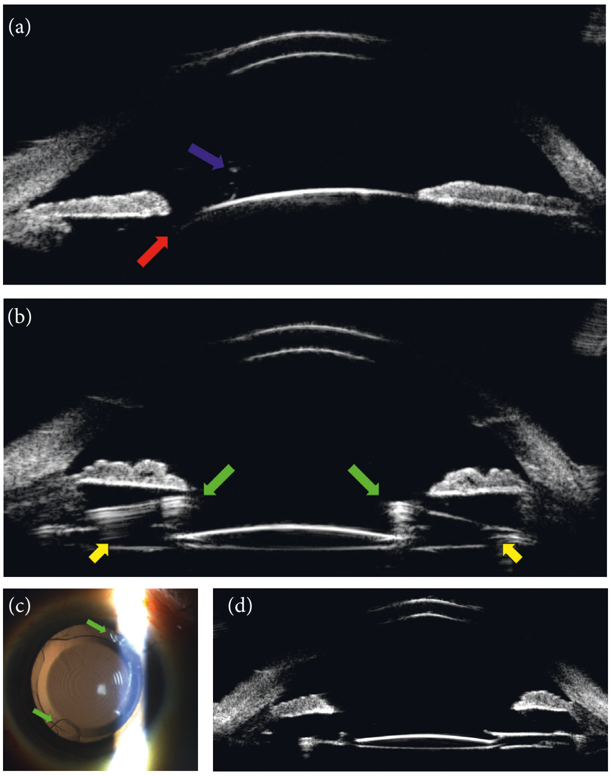


Figure 4: (a) Before surgery, the subluxated lens (red arrow) and vitreous entering the anterior chamber (blue arrow) were detected by ultrasound biomicroscopy. (b) After surgery, the IOL and MCTR were located in the correct positions. Fixation hooks of MCTR (green arrows), haptics of IOL, and MCTR were also observed (yellow arrows). (c) After surgery, extended depth of focus IOL and fixation hooks of MCTR (green arrows) were observed in a slit-lamp examination. (d) Ultrasound biomicroscopy showed the extended depth of focus IOL in the correct position.

procedure during the femtosecond laser process and presumably returns to the normal range within a short period of time [22].

Maintenance of capsular bag stability is an important consideration throughout the surgical process. Stability of the capsular bag and good surgical field of view are critical for reducing surgical complications [23–25]. Iris hooks can restore the subluxated lens to its normal physiological position, fully dilate the capsular bag, prevent further damage to the lens ligament and capsular bag, reduce disturbance to the vitreous, avoid vitreous prolapse, and reduce intraoperative and postoperative complications. Iris hooks also provide a good surgical viewing field and stable operative space for PE, MCTR implantation, and IOL implantation. Moreover, incisions from iris hooks have minimal effects on corneal astigmatism.

Sufficient hydrodissection and hydrodelineation during PE are essential procedures for reducing the pressure on zonular ligaments. For maintaining capsular stability, nucleus rotation is not recommended. Appropriate managements include using low negative pressure and low aspiration power and lowering the height of the bottle appropriately.

Implementation of a capsular tension ring (CTR) is an effective solution to the problems involved in lens subluxation mentioned above. CTRs compensate for weak ligaments in multiple manners. For weak or broken focal ligaments, CTRs can redistribute mechanical force to the ligaments, thereby stretching the equatorial portion of the capsular bag outward. CTRs can also resist postoperative contraction of the capsular bag, reduce the incidence of posterior capsular opacification, and enhance the stability of IOLs [26–28]. Regarding the timing of CTR implantation, CTR implantation earlier than PE can significantly enhance the capsular torque, such that displacement can reach 4.0 mm. We chose to implant MCTR after PE to minimise ligament stress and damage. The intrascleral fixation of MCTR simplifies the surgical procedure and avoids the fraction between the knot and conjunctiva. This technique was also applied in fixation of IOL and achieved ideal outcomes [29]. Compared with traditional CTR implantation, MCTR implantation can avoid IOL displacement caused by progressive abnormal lens ligament and resist CTR displacement resulting from capsular fibrosis and shrinkage.

Successful CCC and good capsular bag fixation provide a good foundation for IOL implantation. Selection of the appropriate IOL is of considerable importance for avoiding long-term complications. Notable long-term postoperative complications include off-centre movement, tilting, or displacement of the IOL; common causes of these complications are asymmetric contraction of the capsular bag, as well as progressive tearing or loosening of the zonular ligaments. Based on the above considerations, mono focal aspherical IOLs were used in 7 eyes (87.5%) in this study, while the extended depth of focus IOL was used in 1 eye (12.5%). During follow-up, no obvious capsular bag contraction or IOL rotation were observed; postoperative vision recovery was stable. In recent years, many studies have confirmed that FLACS combined with CTR implantation can be used to implant many high-tech IOLs, such as toric IOLs and even trifocal IOLs [26, 28]. We chose the extended depth of focus IOL for 1 patient, and the satisfied outcome supports our use of high-tech IOLs to help patients achieve better visual outcomes in the future.

5. Conclusions

Our findings indicate that combined FLACS/PE/IOL implantation/MCTR implantation surgery with iris hook assistance provides simpler procedures, a more stable process, and better visual quality. This surgical technique is an effective and safe method for treating patients with lens subluxation and elevated IOP to improve UCVA and achieve optimal IOP control.

Data Availability

The data supporting the findings of this study are available within the article.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

Acknowledgments

The authors thank Ryan Chastain-Gross, Ph.D. from Liwen Bianji, Edanz Group China (http://www.liwenbianji.cn/ac) for editing the English text of a draft of this manuscript. This work was supported by the National Natural Science Foundation of China (grant numbers: 81974130 and 8210041510), Natural Science Foundation of Hunan Province (grant numbers: 2020JJ4882 and 2021JJ41021) and China Postdoctoral Science Foundation (2021M693556).

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Hindawi
Journal of Ophthalmology
Volume 2022, Article ID 5645752, 9 pages
https://doi.org/10.1155/2022/5645752

Research Article

Comparison of Visual Outcomes and Quality of Life in Patients with High Myopic Cataract after Implantation of AT LISA Tri 839MP and LS-313 MF30 Intraocular Lenses

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Received 17 November 2021; Accepted 4 February 2022; Published 28 February 2022

Academic Editor: Antonio Longo

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Purpose. To investigate the benefits of multifocal lens in patients with high myopic cataract and compare the clinical effects between AT LISA tri 839MP and MPlus LS-313 MF30 intraocular lenses (IOLs) in high myopic eyes. *Methods*. This retrospective cohort study analyzed 60 eyes with axial length >26 mm in 40 patients. Thirty eyes were implanted with MF30, and the remaining 30 eyes were implanted with 839MP. Postoperative uncorrected distance visual acuity (UDVA), best corrected distance visual acuity (BCDVA), uncorrected intermediate visual acuity (UIVA) and uncorrected near visual acuity (UNVA), defocus curve, modulation transfer function (MTF) curve, Strehl ratio (SR), and complications were compared between the two groups. *Results*. All vision outcomes were significantly improved in both groups ($p < 0.05$). There was no significant between-group difference in UDVA at 1 and 3 months postoperatively ($p > 0.05$). However, UIVA and UNVA were significantly better in the 839MP group ($p < 0.05$). The VF-14 score, especially for near vision quality, was significantly higher in the MF30 group (2.2 ± 0.9 vs. 0.8 ± 0.7; $p \leq 0.001$). The SR of both groups significantly increased postoperatively ($p < 0.05$). All the 3-month MTF curve values (MTF 10 total, MTF 10 internal, MTF 30 total, and MTF 30 internal) were significantly better in the 839MP group ($p < 0.05$). Meanwhile, all the high-order aberration values (coma, spherical aberration, and trefoil) were significantly greater in the MF30 group ($p < 0.05$). *Conclusion*. Multifocal IOL implantation achieves good quality of distance, intermediate, and near vision in patients with high myopia, improving their quality of life. Both 839MP and MF30 IOLs can provide good distance vision, but 839MP performs better in near and intermediate vision. However, for some patients with an extra-long optic axis, MF30 may be a good choice because of its wider range of degrees.

1. Introduction

The incidence of high myopia is increasing worldwide, with the number of patients with high myopia and complicated cataracts markedly increasing [1]. Patients expect spectacle-free vision after cataract surgery. Surgery for highly myopic eyes is challenging. The most common surgical strategy is implanting monofocal intraocular lens (IOL) and leaving −2.5 D to −3.0 D myopia. However, although this achieves excellent near vision, it is also associated with loss of regulation and stereoscopic vision in the active state after surgery. The development of cataract phacoemulsification and advances in surgical technology and IOL calculation methods have greatly improved the predictability of refractive results after cataract surgery for high myopia. Although still controversial, an increasing number of multifocal IOLs (MIOLs) have been used in highly myopic eyes. Some studies [2–4] have also reported full range of vision after MIOL implantation in many patients with high myopia, significantly improving the patients' quality of life (QOL). Given their multiple focus, these IOLs provide good vision for activities at multiple distances [5–7]. However, they are also complicated by undesirable effects such as glare, halos, and reduced contrast sensitivity.

At present, only a limited type of MIOLs, including AT LISA tri 839MP (Carl Zeiss Meditec AG, Jena, Germany) and MPlus LS-313 MF30 (Oculentis, Holland), can be used in high myopia due to the limitation of the degree range. Both 839MP and MF30 have been reported to achieve good outcomes in patients with high myopia [8,9]. However, few studies have compared the visual quality between these two different lenses in patients with high myopic cataract. As such, this study aimed to compare the clinical benefits between AT LISA tri 839MP and MPlus LS-313 MF30 IOLs in high myopic cataract. Toward this goal, we evaluated the postoperative visual quality and compared the feasibility of these two IOLs in patients with high myopia.

2. Methods

2.1. Study Design and Participants. This was a retrospective cohort study of 60 eyes from 40 patients diagnosed with cataract and high myopia who underwent phacoemulsification cataract extraction combined with MIOL implantation at Shanghai Heping Eye Hospital, Shanghai, China, between September 2018 and July 2021. The inclusion criteria were as follows: age >18 years, length of optic axis >26 mm, irregular corneal astigmatism <0.3 um; postoperative corneal astigmatism ≤0.75 D, clear intraocular media, available to comply with examination procedures, and written informed consent for participation in the study. The exclusion criteria were pupil centroid shift; pupil size >5 mm or <2 mm in dim light; amblyopia; previous ocular surgery; ocular pathologies such as diabetic retinopathy, macular degeneration, and glaucoma with field defects; lifestyle; and work-related factors, such as pilots, professional drivers, and architects.

Among the 40 patients, there were 3 patients with one eye implanted in MF30 and another eye in 839MP; they simultaneously belonged to both groups, so there were totally 23 patients (30 eyes) and 20 patients (30 eyes) who underwent regional refraction MIOL (MF30) implantation and diffraction MIOL (839MP) implantation categorized to the MF30 group and 839MP group, respectively. Patients in the two groups were enrolled under the same conditions. All patients were followed up for 3 months. The characteristics of the lenses are listed in Table 1.

Table 1: The properties of the two IOLs used in the present study.

Name	AT LISA tri 839MP	MPlus LS-313 MF30
Optics	Diffractive	Segmental refractive
Material	Hydrophilic acrylic	Hydrophilic acrylic
Near add (D)	+3.33	+3.00
Dioptric range (D)	0.0 to +32.0	−10.0 to +35.0
Edge design	360° square edge	360° square edge
A constant	118.6	118.5
Refractive index	1.48	1.48
Optic diameter (mm)	6.0	6.0
Overall diameter (mm)	11.0	11.0

2.2. Preoperative Examination. Preoperative examination included (1) uncorrected distance visual acuity (UDVA); (2) best corrected distance visual acuity (BCDVA); (3) uncorrected near visual acuity (UNVA); (4) subjective refraction; (5) corneal topography assessed with Pentacam Comprehensive Eye Scanner (Oculus Optikgeraete GmbH; Wetzlar, Germany); (6) slit-lamp biomicroscopy of the anterior and posterior segments with a Volk lens, optical coherence tomography, scanning laser ophthalmoscopy, retinal fiber nerve layer, Pascal tonometry, and biometry (IOL-Master 700; Carl Zeiss Meditec AG); (7) higher-order aberrations (HOA); and (8) Strehl ratio (SR).

2.3. Surgical Technique. The surgery was performed by the same senior physician, and standard phacoemulsification was used for cataract extraction. In all patients, topicamide was used to fully dilate the pupil, and cocaine eye drops were used for surface anesthesia. A 2.2 mm transparent corneal incision was made at 130°, and a central continuous circular capsulorhexis was performed with a diameter of 5.5 mm. After water separation and stratification, phacoemulsification was performed to extract the lens nucleus, and the I/A system was used to extract the lens cortex. An IOL was implanted after the viscoelastic agent was injected into the anterior chamber and pouch. The I/A system was used to remove the viscoelastic agent, and the incision was watertight. The IOL power was calculated using optical biometry (IOL-Master 700; Carl Zeiss Meditec, Jena, Germany) and Barrett formulas. The target refraction was 0 in the operative eye with an axis between 26 mm and 30 mm. Meanwhile, considering that the ultralong eye axis is prone to farsighted drift, the target diopter was kept within −0.5 D in the surgical eyes with an axis >30 mm.

2.4. Postoperative Follow-Up and Assessments. The patients were followed up at 1 week, 1 month, and 3 months postoperatively. Patient satisfaction was assessed using the modified Vision Acuity and Visual Function Index 14 (VF-14) [10] at 3 months. The VF-14 has a total of 14 questions. A score was assigned to each answer, and a higher score indicated poorer QOL. The patients were also asked questions about their satisfaction and dissatisfaction with vision and whether there was no vision disorder in daily life [11]. In addition, we recorded any side effects or complications during the 3-month period.

2.5. Outcome Measures. The primary outcome measure was visual acuity measured according to UDVA and BCDVA at 5 m; UIVA at 80 cm; and UNVA at 40 or 33 cm. Visual examination was performed twice under sufficient lighting, and the international standard visual acuity table was used. The secondary outcome measures were as follows: (1) HOA such as coma, spherical, trefoil, and secondary astigmatism measured using internal and total values at a 3-mm pupil size with the HOYA iTrace ray-tracing system (Tracey Technologies, Houston, TX, USA); (2) the SR was also measured using internal and total values at a 3-mm pupil size with the HOYA iTrace ray-tracing system; and (3) defocus curves for each MIOL, obtained by plotting the mean visual acuity with 11 values of defocus from +2.0 D to −3.0 D on the ETDRS chart in logMAR units. The defocus curve simulates the patient's visual acuity at different distances by placing positive and negative lenses in 0.5 D increments in front of the patient's eyes. The measurements were performed by adding lenses to BCDVA.

2.6. Statistical Analysis. Measurement data were expressed as $X \pm S$. Between-group comparisons by sex were performed using the χ^2 test. Age, axial length (AL), anterior chamber depth (ACD), lens thickness (LT), white-to-white (WTW), and dysfunctional lens index (DLI) were compared using the *t*-test. Repeated-measurement analysis of variance was used for between-group comparison of pre- and postoperative visual acuity, HOA, and defocus curve. All statistical analyses were performed using SPSS 17.0. Statistical significance was set at $p < 0.005$.

3. Results

3.1. Baseline Characteristics. In total, 40 patients (60 eyes) were finally included in the analysis; of them, 30 eyes belonged to the MF30 group and 30 eyes belonged to the 839MP group. There was no significant difference in age (59.8 ± 9.2 vs. 54.4 ± 12.5 years, $p = 0.065$), the proportion of men (43.5% [$n = 10$] vs. 35.0% [$n = 7$], $p > 0.05$), and the proportion of women (56.5% [$n = 13$] vs. 65% [$n = 13$], $p > 0.05$) between the MF30 and 839MP groups. There were also no significant between-group differences in the preoperative UDVA and BCVA. In addition, optical biometry, such as AL, ACD, LT, and WTW, and the severity of cataract indicated by DLI were also not significantly different (Table 2).

3.2. Visual Outcomes. Postoperative refractive status of patients in the two groups were mostly emmetropia. The spherical equivalent measured by automatic optometry were -0.52 ± 0.48 D in the MF30 group and -0.08 ± 0.16 D in the 839MP group. Compared with the MF30 group, the 839MP group showed significantly better 3-month UDVA (0.10 ± 0.10 vs. 0.03 ± 0.07, $p \leq 0.001$), BCDVA (0.09 ± 0.09 vs. 0.03 ± 0.05, $p = 0.002$), and UNVA (0.20 ± 0.11 vs. 0.07 ± 0.07, $p \leq 0.001$). UNVA was also significantly different between the two groups at all three visits. Similarly, the 3-month UIVA was significantly better in the 839MP group (0.23 ± 0.11 vs. 0.05 ± 0.08, $p \leq 0.001$) (Figure 1).

3.3. Defocus Curve. The postoperative defocus curves of the two groups are shown in Figure 2. In the 839MP group, defocus curves showed a bimodal pattern, with the far and near focus at 5 m and 40 cm, respectively; the corresponding peaks were (0.030 ± 0.036) logMAR and (0.145 ± 0.069) logMAR, providing better visual acuity than 0.1 logMAR within +0.5 to −0.5 D and 0.2 logMAR within −1.0 to −1.5 D and −3.0 D. Meanwhile, the defocus curve in the MF30 group only showed a one-peak shape, with the focal point at 5 m. The corresponding peak value was 0.131 ± 0.099 logMAR, providing better visual acuity than 0.2 logMAR within +0.5 D to −0.5 D. Significant differences between the MF30 group and 839MP group defocus curves were detected for the following vergences: +0.5, 0.0, −0.5, −1.0, −2.0, −2.5, and −3.0 D (all $p < 0.05$) (Figure 2).

Table 2: The baseline characteristics and VF-14 scores of patients in both IOL groups in the study.

Characteristics	Group 1		Group 2		p value
	Mean	SD	Mean	SD	
Age	59.8	9.2	54.4	12.5	0.065
Axial length (mm)	28.79	2.56	27.97	1.90	0.167
Depth of anterior chamber (mm)	3.35	0.28	3.38	0.28	0.627
Lens thickness (mm)	4.44	0.32	4.32	0.33	0.158
White-to-white (mm)	11.8	0.4	11.8	0.5	0.599
VF-14 score	2.2	0.9	0.8	0.7	≤0.001
Preoperative DLI	2.63	2.24	3.60	2.60	0.127

3.4. Quality of Life and Objective Visual Quality. All patients answered the VF-14 questionnaire. The VF-14 score was significantly higher in the MF30 group (2.2 ± 0.9 vs. 0.8 ± 0.7, $p \leq 0.001$) (Table 2). Meanwhile, there were minimal differences in the level of satisfaction between the two groups. However, the MF30 group had significantly lower satisfaction with near vision quality. Similar results were observed for objective visual quality, such as the SR and MTF curve. Both postoperative total SR and internal SR were significantly increased compared with preoperative values of the two groups, and the difference was statistically significant. However, the range was larger in the 839MP group than in the MF30 group (Figure 3). In addition, both the 3-month MTF 10 total (0.173 ± 0.065 vs. 0.376 ± 0.152, $p \leq 0.001$) and MTF 10 internal (0.166 ± 0.066 vs. 0.502 ± 0.175, $p \leq 0.001$) were significantly higher in the 839MP group. Furthermore, the MF30 group showed significantly lower MTF 30 total (0.056 ± 0.017 vs. 0.108 ± 0.155, $p \leq 0.001$) and MTF 30 internal (0.056 ± 0.026 vs. 0.162 ± 0.101, $p \leq 0.001$) at 3 months (Figure 4).

3.5. High-Order Aberrations and Postoperative Complications. At 3 months postoperative, almost all the HOA values (coma, spherical aberration, trefoil) were significantly greater in the MF30 group than in the 839MP group ($p < 0.05$) (Table 3). No serious postoperative complications were noted during the 3-month follow-up in either group. However, there were three cases of posterior capsule opacification in the 839MP group, and this caused diminution of vision and needed Nd:YAG laser capsulotomy. In the MF30 group, one patient developed

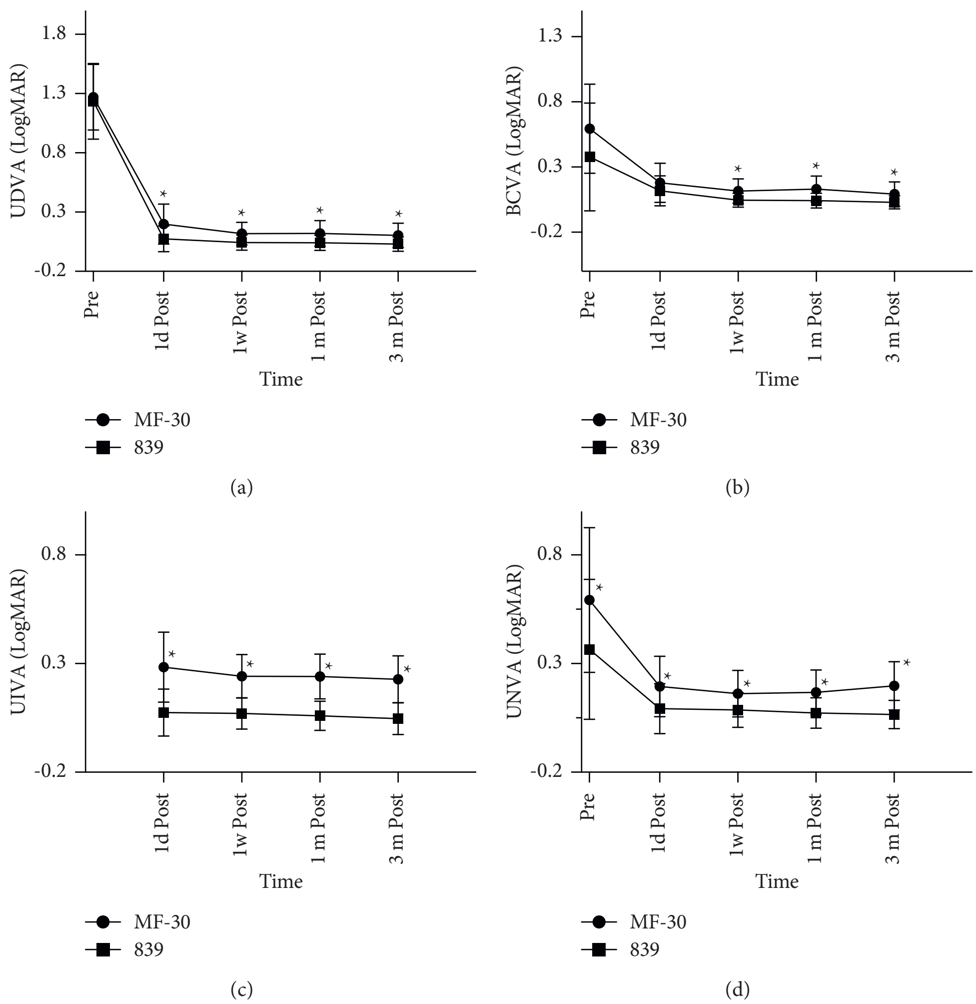

Figure 1: The preoperative and postoperative visual outcomes of two MIOL groups in 3 months. All data were presented as mean ± SD. (a) UDVA (logMAR). (b) BCVA (logMAR). (c) UIVA (logMAR). (d) UNVA (logMAR). $^{*}p < 0.05$.

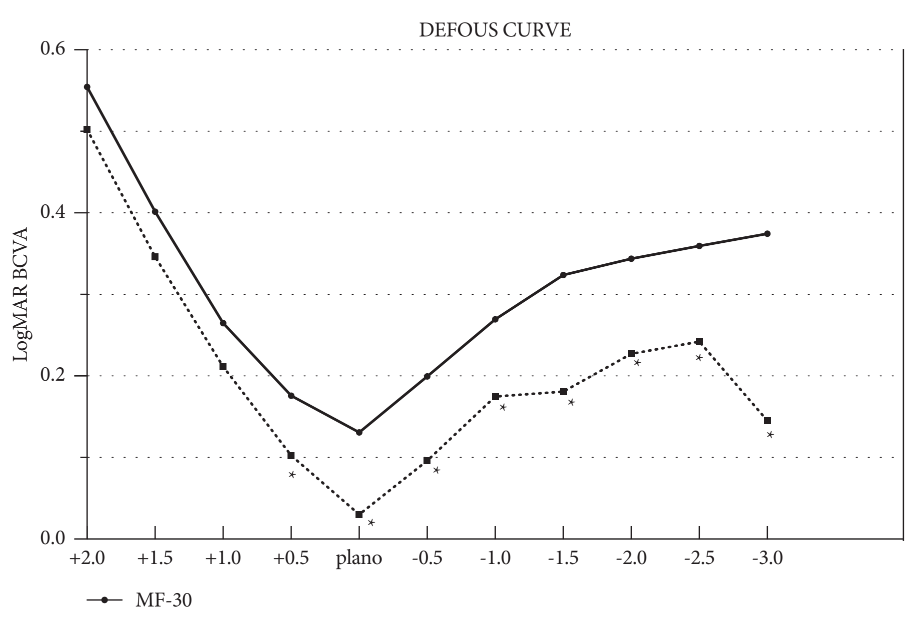

Figure 2: The MTF 10 and 30 (both total and internal) of two MIOL groups, included preoperative and postoperative at 3 months. A comparision of MTF 10 and 30 (both total and internal) between two groups after surgery at 3-month follow-up. All data were presented as mean ± SD. *Significant difference ($p < 0.05$).

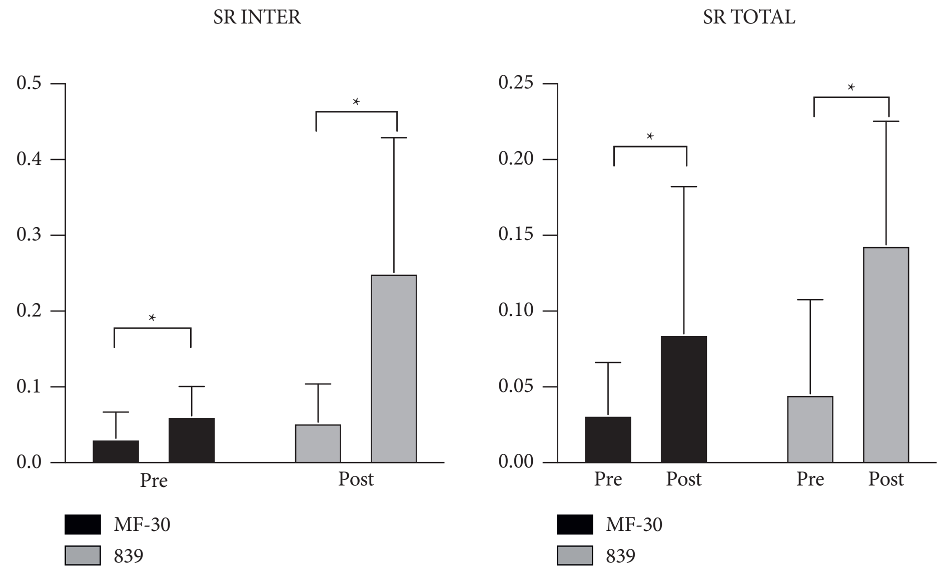

Figure 3: Binocular defocus curves in MF30 and 839MP groups. All data were presented as mean. *Significant difference ($p < 0.05$).

asymmetric constriction of the lens pouch that caused the IOL to shift upward.

4. Discussion

Advances in refractive cataract have led to the development of IOLs with ingenious design and different functions, such as trifocal IOLs and segmental refractive IOLs. Both 839MP and MF30 are frequently used in high myopic cataracts owing to their wide range of spherical powers. Good outcomes of MIOLs in eyes with high myopia have been reported in recent years [12–15]. However, there are few reports on the optimal IOL for patients with high myopia. Our study evaluated the postoperative visual quality between the two multifocal IOLs in high myopic cataract and compared the clinical benefits and the feasibility of these two IOLs in patients with high myopia.

The results of this study showed that 1-month UDVA was almost as similar as that at 3 months in both 839MP and MF30. The patients' far, medium, and near visual acuity and diopter reached the expected refractive correction. Furthermore, most patients had stable visual acuity 1 month after surgery, and the operation was predictable. Compared with preoperative eyesight, postoperative eyesight was improved as indicated by a significant difference between baseline and postoperative UDVA, BCDVA, UIVA, and UNVA in both groups. Similarly, the postoperative SRs were significantly increased in the two groups. This increase in SRs indicated the improvement of not only vision but also vision quality. Collectively, these results support the effectiveness of multifocal IOLs.

However, the UIVA and UNVA in the 839MP group were significantly better than those in the MF30 group. This indicates that trifocal IOLs can provide better whole-course visual acuity in patients with high myopia. Patients in the 839MP group reported good satisfaction with far, medium, and near visual acuity 3 months postoperatively, consistent with previous results [13,14,16]. This may be because the MF30 IOL has a lower attachment degree of near power (+3.00 D). High myopic eyes require more near power to reach the same level as the normal eye.

Several clinical studies have shown that after implantation of regional refraction, MIOL patients can not only obtain good near and far vision [17–19] but also have almost no limitation in middle-distance operation such as using computers [20]. In contrast, we found a different result. Analysis of defocus curves at 3 months postoperative showed a bimodal pattern in the 839MP group, with the far and near focus at 5 m and 40 cm, respectively. Meanwhile, the defocus curve in the MF30 group only showed a one-peak pattern, with a focal point at 5 m. This could be because all patients in this study had high myopic cataracts. When used in emmetropia, regional refraction IOLs can still provide a continuous vision range. The 839MP group had better vision than the MF30 group at the following vergences: +0.5, 0.0, −0.5, −1.0, −2.0, −2.5, and −3.0 D, and the difference was significant. This further confirms the result that trifocal IOLs achieve better medium and near vision and are more suitable for patients with middle-distance requirements such as those with computer work.

Objective visual quality can be quantified by the MTF curve, SR, and other indicators [21,22]. HOYA iTrace can directly collect PSF to calculate SRs and translate it into an MTF curve. The MTF curve reflects the different spatial frequencies in the clear degree of imaging. A low spatial frequency usually reflects the ability to see the object contour, while a high spatial frequency reflects the ability to distinguish fine objects. In this study, we used the MTF values under a spatial frequency of 10 to evaluate far visual acuity and MTF values under a spatial frequency of 30 to evaluate near visual acuity. The improvement in visual quality was reflected by comparing between pre- and postoperative SR values. The results showed that the total

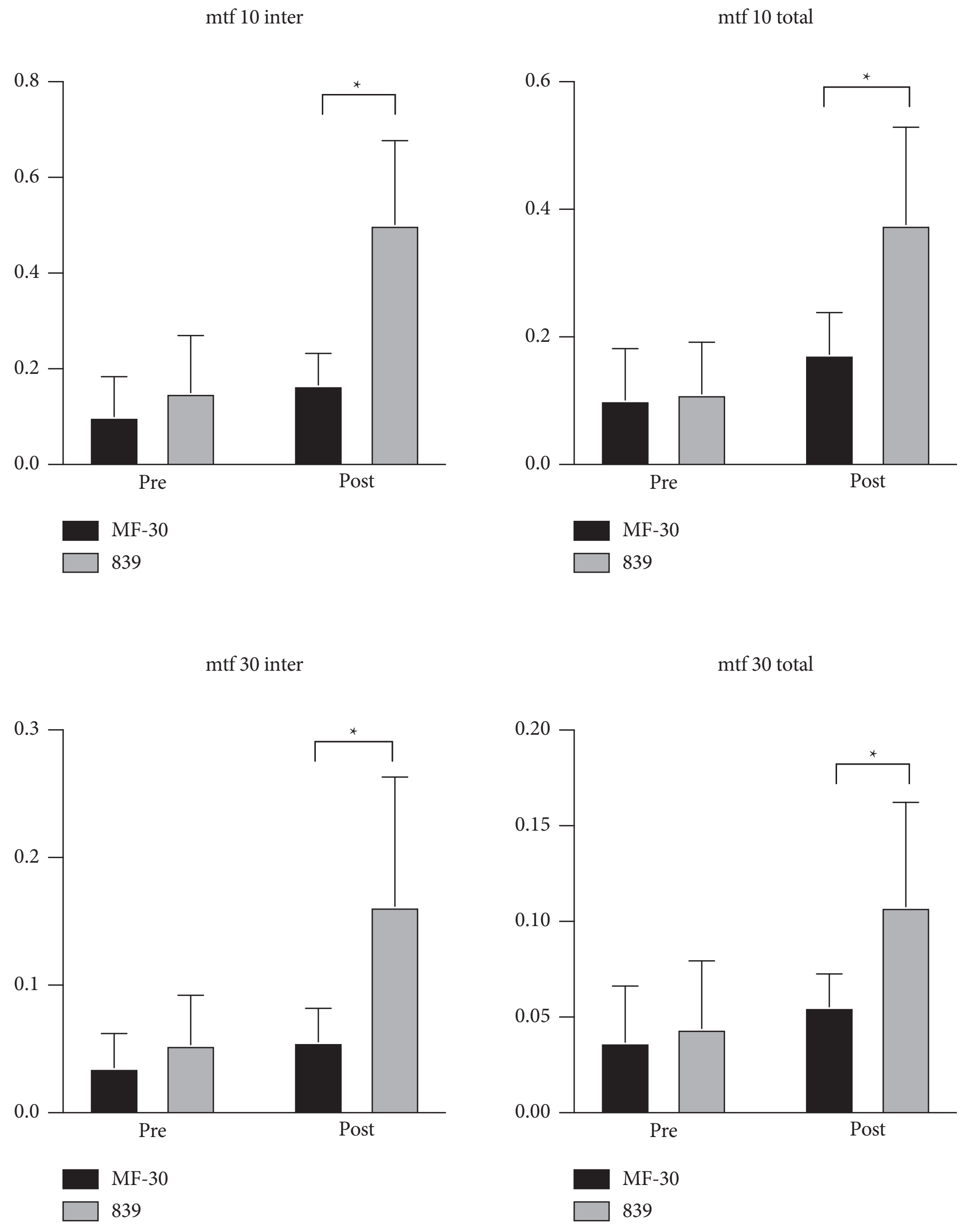

Figure 4: The comparision of preoperative and postoperative Strehl ratio (SR) total and internal of two MIOL groups at 3 months. The ordinate means the specific value of SR. All data were presented as mean ± SD. *Significant difference ($p < 0.05$).

and intraocular SR values were significantly improved after surgery in both groups, and the difference between pre- and postoperative values was significant. This suggests that both IOLs can effectively improve visual quality. Intergroup comparisons showed that MTF 10 and MTF 30 in both internal and total eye groups were improved after surgery. However, the 839MP group showed significantly better improvements than the MF30 group. These results indicate that trifocal IOLs can result in more stable and excellent visual quality than segmental refractive IOLs in patients with high myopia combined with cataracts.

Similar results were observed for HOAs. Some patients had excellent postoperative vision but still complained of blurred vision, glare, and decreased night vision, and this is closely related to HOAs. At 3 months postoperatively, both coma and trefoil, as measured by the iTrace ray-tracing system, were greater in the MF30 group than in the 839MP group. Some studies have analyzed the coma of regional refraction MIOL and found that the values of both the far and near optical regions were 0. However, when measured by traditional wavefront aberration instruments, the light emitted from off-axis points is refracted through the upper and lower optical planes of the IOL, resulting in a large vertical coma [23,24]. Although this design lengthens the depth of focus and improves near vision, the instrument cannot be distinguished during measurement [25,26]. Automatic optometry cannot recognize neither, so the measurement result usually shows a myopic astigmatism error about −1.25 D. Meanwhile, the concentric diffraction ring design on the rear surface of the diffracted MIOL has lesser

Table 3: High-order aberrations of two different MIOL groups at 3 months after surgery in 60 eyes of 40 patients.

Aberrations	Group 1		Group 2		p value
	Mean	SD	Mean	SD	
Preoperative HOA total (μ)	1.734	3.914	3.157	14.827	0.613
Preoperative HOA internal (μ)	1.736	3.924	3.151	14.845	0.616
Postoperative total					
HOA (μ)	0.296	0.054	0.137	0.096	≤0.001
Coma (μ)	0.160	0.047	0.052	0.038	≤0.001
Spherical (μ)	0.030	0.040	0.000	0.046	≤0.001
Trefoil (μ)	0.173	0.062	0.096	0.109	0.011
Secondary astigmatism (μ)	0.039	0.021	0.033	0.042	0.002
Postoperative internal					
HOA (μ)	0.291	0.063	0.119	0.101	≤0.001
Coma (μ)	0.154	0.050	0.050	0.035	≤0.001
Spherical (μ)	0.014	0.031	−0.020	0.038	≤0.001
Trefoil (μ)	0.168	0.066	0.064	0.091	≤0.001
Secondary astigmatism (μ)	0.037	0.022	0.032	0.043	0.510

interference on aberration measurement and a smaller corresponding coma. Multiple clinical studies [18] have reported that coma and HOAs such as coma and trefoil in implanted regional refraction MIOL cannot adequately explain postoperative visual quality of patients. Furthermore, instrumental measurement is greatly affected by the additional fan-shaped optical area, and thus, the reference value is limited.

The VF-14 scores were consistent with the visual outcome assessment findings. Overall satisfaction was very high in both groups despite limitations in fine object recognition, such as reading newspapers and threading a needle. Near vision quality was significantly better in the 839MP group, but there was no remarkable difference in driving comfort. This might be due to good objective outcomes at distance vision in both groups. Another difference between the two groups was the difficulty in walking up and down the stairs. The VF-14 scores showed worse adaptation in the MF30 group. This might be because if IOLs are placed vertically, the lower part of the lens is attached with +3.0 D near-area. When looking down, the optical axis may enter the eye through the near area, resulting in blurred vision and reduced sense of distance and making it difficult to walk up and down the stairs. This is more common in patients with large pupils.

We also surveyed the patients about photic phenomena, such as glare and halo. The incidence and perception level of halo and glare were significantly lower in the MF30 group. One possible explanation for this finding is that unlike the AT LISA tri 839MP IOL, the MF30 IOL does not have diffractive steps. Many diffractive steps are responsible for glare and halo [27]. Patients in the MF30 group usually complained about a triangle-shaped halo while driving or using a mobile phone. However, both groups reported good driving scores, which could be explained by the fact that after 3 months of neuroadaptation, glare and halo effects were no longer perceived by the patients as detrimental for driving. However, this hypothesis requires further research in a larger sample with a longer follow-up period.

In addition, we found 3 cases of severe posterior capsular opacities within 3 months postoperatively in 839MP group, and this required YAG laser posterior capsulotomy to improve vision. Although this complication was also observed in the MF30 group, the severity was lower than that in the 839MP group. This may be related to the fact that both of these IOLs are hydrophilic acrylates. In addition, patients with posterior capsular opacities were obviously younger. Furthermore, high myopia is not an influencing factor of increased probability of occurrence [28]. Concurrently, one patient in the MF30 group had obvious anterior capsule contraction, leading to an upward shift in the effective position of the IOL. This caused the optical axis to mostly reach the eye through the near-visual area and resulted in blurred vision and decreased visual quality. We will continue to monitor other patients to determine if similar events occur.

This study has some limitations. First, the sample size was inadequate to obtain robust conclusions. Second, we could not obtain reading parameters because standardized reading charts were not available. Moreover, it is difficult to determine the incidence of photic phenomena because many IOL studies use self-made questionnaires to capture patient-related outcomes, and these questionnaires are not standardized. Third, this was not a randomized study; the patients and the surgeon were aware of the type of lens used. Despite these limitations, this study provides important data on the comparison between 839MP and MF30 for high myopia. In further study, we will expand the sample size and extend follow-up time to obtain more data.

5. Conclusion

MIOL achieves good distant, intermediate, and near visual quality in patients with high myopia and cataract and significantly reduces postoperative dependence on glasses, improving QOL. Furthermore, the patients did not show retinal vulnerability in this study but were still required long-term follow-up, especially routine check of the retina. In particular, both 839MP and MF30 can provide good distant vision, but 839MP has superior intermediate and near vision benefits. Meanwhile, MF30 has a wider range of degrees and may thus be the optimal choice for patients with ultralong ocular axis. Moreover, 839MP is two times more costly than MF30 and is associated with a high incidence of posterior capsule opacification in young patients. These factors should be considered when selecting the most suitable IOL.

Data Availability

The data sets generated and/or analyzed during the current study are available from the corresponding author on reasonable request and approval by the institutional ethics committee.

Disclosure

Jiying Shen and Limei Zhang are co-first authors. Jin Yang and Haike Guo are co-corresponding authors.

Conflicts of Interest

All the authors declare that they have no conflicts of interest.

Authors' Contributions

Jin Yang and Haike Guo designed the research; Jiying Shen, Limei Zhang, and Shuang Ni collected the data; and Lei Cai and Jiying Shen analyzed the data. Jiying Shen and Limei Zhang co-wrote the manuscript. Jin Yang and Haike Guo critically revised the manuscript. Jiying Shen and Limei Zhang contributed equally to this work. Jin Yang and Haike Guo contributed equally to this work.

Acknowledgments

This work was funded by the Chinese National Nature Science Foundation (82171039) and The Scientific Research Fund of Shanghai Municipal Health and Family Planning Commission (201840239).

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