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Research article

Analysis of intraocular lens decentration and tilt after femtosecond laser-assisted cataract surgery using swept-source anterior optical coherence tomography

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ABSTRACT

Objective: To evaluate and compare the magnitude of intraocular lens (IOL) decentration and tilt following conventional and femtosecond laser-assisted cataract surgery (FLACS) using swept-source anterior optical coherence tomography (*SS*-OCT).
Methods: In this retrospective observational study, we enrolled patients who underwent conventional cataract surgery or FLACS with the implantation of hydrophobic 1-piece monofocal IOL. The magnitude of IOL decentration and tilt were measured using *SS*-OCT. Visual acuity, intraocular pressure, spherical equivalent, axial length, contrast sensitivity, and satisfaction questionnaire were evaluated before and one-month post-surgery. Additionally, postoperative internal cylinder measurements were obtained using a wavefront aberrometer. Correlation factors between each parameter and IOL decentration or tilt were analyzed.
Results: This study included 100 eyes from 100 patients. Mean IOL decentration and tilt were 0.21 ± 0.13 mm and 5.01 ± 1.49°, respectively. Conventional cataract surgery (versus FLACS, $P = 0.001$) and male sex (versus female, $P = 0.047$) were significantly correlated with higher postoperative decentration. Preoperative lens diameter ($P < 0.001$), preoperative lens tilt ($P = 0.007$), and preoperative intraocular pressure ($P = 0.027$) were correlated with higher postoperative tilt. Fifty eyes that underwent FLACS demonstrated mean postoperative decentration of 0.21 ± 0.13 mm and tilt of 4.64 ± 1.48°. Compared with the conventional surgery group, the FLACS group significantly differed in postoperative decentration (0.30 ± 0.12 mm, $P < 0.001$) but not in tilt (5.03 ± 1.35°, $P = 0.173$). Postoperative visual acuity did not significantly differ between the two groups.
Conclusion: Patients who underwent FLACS demonstrated better IOL decentration and tilt than those who underwent conventional cataract surgery one-month post-surgery. However, differences in IOL decentration and tilt did not affect postoperative visual acuity.

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1. Introduction

Cataract surgery is performed to restore visual acuity and improve the quality of life for patients by replacing the opacified crystalline lens with an intraocular lens (IOL). Although surgical techniques and materials have evolved considerably, postoperative complications such as IOL tilt and decentration continue to pose challenges to achieving optimal visual outcomes.

Recently, the impact of IOL tilt and decentration on visual outcomes and patient comfort has been increasingly recognized [1–4]. Improper positioning of the IOL can induce optical aberrations and compromise the effective visual axis. Notably, even slight IOL decentration (≥0.4 mm) or tilt (≥7°) can lead to suboptimal vision and patient dissatisfaction [5].

Previous studies have revealed associations between IOL tilt, decentration, and various preoperative factors. Gu et al. highlighted the significance of preoperative lens position and axial length [6], whereas Fan et al. and Tan et al. identified factors such as male sex, preoperative trauma, high myopia, vitrectomy history, and lens subluxation [7,8]. Another studies have explored the impact of manual capsulorhexis and haptic design or orientation on postoperative decentration and tilt [9–11].

Advancements in imaging technologies, such as swept-source optical coherence tomography (*S*S-OCT) and 3D OCT image reconstruction, have enabled more accurate assessment and automated quantification of IOL tilt and decentration [6,12–15]. This facilitates a comprehensive understanding of the spatial relationship between the IOL and the capsular bag, consequently facilitating a deeper exploration of the effects of postoperative decentration and tilt on visual acuity, dysphotopsia, and wavefront aberrations [16–18].

Given the significant influence of IOL alignment on visual outcomes, we aimed to identify preoperative risk factors for postoperative decentration and tilt using anterior segment *S*S-OCT. We particularly focused on the potential impact of femtosecond laser-assisted cataract surgery (FLACS), which can improve anterior capsulotomy and reduce stress on intraocular structures such as zonulae by delivering less phacoemulsification energy [19–21]. Through this study, we aimed to enhance knowledge of IOL alignment and potentially refine strategies to improve patient satisfaction with visual outcomes.

2. Methods

This retrospective study was conducted at a single center (Asan Medical Center, Seoul) between from 2021 to 2022. Exclusion criteria included poor dilation, severe zonular weakness, other ocular diseases such as corneal pathologies, glaucoma, uveitis, strabismus, retinal pathologies, ocular surgical history, long or short axial length (>26.0 or <22.0 mm), and significant K astigmatism (>1.5 D). In cases where both eyes met the criteria, one eye was randomly selected. This retrospective study received approval from the institutional review board of Asan Medical Center, Seoul, South Korea (2023-1466). All procedures adhered to the principles of the Declaration of Helsinki. Prior to cataract surgery, all participants provided written informed consent for the utilization of their clinical data.

All patients underwent comprehensive ophthalmic examinations before the operation, including uncorrected and corrected distance visual acuity (UDVA and CDVA, respectively), intraocular pressure (IOP), spherical equivalent (SE), cataract grade assessed using Lens Opacities Classification System III (LOCS III), surgical method (FLACS vs. conventional), relevant medical history (such as diabetes and previous vitrectomy), and questionnaire responses regarding distant vision satisfaction, glare, and halo perception.

2.1. Surgical technique

All surgeries were performed by a single, experienced surgeon (HL), employing two surgical techniques: conventional cataract surgery and FLACS (CATALYS™ Precision Laser System, Johnson & Johnson). A hydrophobic 1-piece IOL (Eyhance non-toric, Johnson & Johnson) was implanted, with the lens center aligned with the visual axis. The capsulorhexis center coincided with the lens center and had a size of 5.0 mm. Before the conclusion of every surgery, continuous 360° IOL-capsulorhexis overlap was confirmed. Postoperative topical medications included levofloxacin hydrate 1.5 % (Cravit 1.5 %, Santen Pharmaceutical) four times daily, prednisolone acetate 1.0 % (Predforte 1.0 %, Allergan, Inc.) four times daily, ketorolac tromethamine 0.45 % (Acuvail, Allergan, Inc.) two times daily, and cyclosporin 0.1 % (Ikervis 0.1 %, Santen Pharmaceutical) once daily.

2.2. Pre- and postoperative examinations

Baseline assessments were conducted before and one month after cataract surgery. IOL decentration, tilt, and lens diameter were evaluated using swept-source anterior optical coherence tomography (CASIA II, TOMEY) under mesopic conditions without dilation eyedrop. For the right eye, an axis of 180° indicated the temporal side, whereas an axis of 180° indicated the nasal side for the left eye. To ensure axis orientation consistency between the left and right eyes, we transformed the axis 180° of the right eye into axis 0, and axis 0 of the right eye into axis 180° before analysis. This adjustment was necessary to align the axis orientations between the left and right eyes and achieve uniformity in our statistical evaluations. Wavefront aberrometry (OPD Scan III, NIDEK) was employed to measure total, corneal, and internal cylinder aberrations. Additionally, anterior chamber depth, lens thickness, and axial length were measured using IOL Master 700 (ZEISS).

2.3. Statistical analysis

Statistical analyses were conducted using SPSS software version 25.0 (IBM Corp., Armonk, NY, USA). The normality of the data was analyzed using the Shapiro–Wilk test. Quantitative data were presented as mean ± standard deviations (SD) and were compared using paired t-tests for baseline and one-month postoperative values. Independent t-tests were employed to compare the FLACS and conventional surgery groups one month after surgery. Stepwise multiple linear regression analyses were performed to identify preoperative factors influencing IOL tilt and decentration after 1-month. Statistical significance was set at $P < 0.05$.

3. Results

A total of 100 eyes from 100 patients who met the inclusion criteria were included in the analysis. Baseline ocular and clinical characteristics were generally balanced between the FLACS and conventional cataract surgery groups (Table 1). The mean age of the patients was 70.36 ± 9.85, with an average nuclear opacity of 4.29 ± 0.71, cortical opacity of 3.03 ± 1.67, and posterior subcapsular opacity of 2.10 ± 1.96 based on LOCS III grading. The number of patients who underwent FLACS and conventional cataract surgery was the same.

Table 2 displays changes in ocular parameters, including lens tilt and decentration after cataract surgery. The value of spherical equivalent decreased from −0.43 ± 1.94 to −0.29 ± 0.53 after surgery ($P = 0.535$), and CDVA was significantly improved from LogMAR 0.51 ± 0.55 to 0.07 ± 0.15 ($P < 0.001$) and accompanied by a decrease in IOP and corneal cylinder value on the OPD scan. The total cylinder on the OPD scan revealed no apparent difference before and after surgery ($P = 0.412$). Decentration on AS-OCT significantly increased from 0.21 ± 0.13 to 0.25 ± 0.13 before and after surgery ($P = 0.010$), with the axis shifting from 285.5 ± 123.9 to 345.2 ± 116.8 in the superior temporal direction ($P < 0.001$). We observed no significant difference in the degree and axis of tilt ($P = 0.355$ and $P = 0.786$, respectively).

Tables 3 and 4 present the results of a univariate regression analysis aiming to identify preoperative factors influencing IOL instability. According to these tables, decentration appeared to be related to male sex and conventional cataract surgery technique, whereas tilt was related to crystalline lens diameter, preoperative lens tilt, IOP, and corneal cylinder. The multivariate analysis results are presented in Table 5. In the multivariate analysis, the male sex was associated with increased decentration (OR = 0.06; 95 % CI 0.01, 0.11; $P = 0.047$), and the FLACS group revealed a smaller postoperative decentration (OR = −0.09; 95 % CI -0.14, −0.04; $P = 0.001$). Factors related to IOL tilt included preoperative lens diameter (OR = 0.71; 95 % CI 0.38, 1.05; $P < 0.001$), preoperative lens tilt (OR = 0.23; 95 % CI 0.06, 0.40; $P = 0.007$), and preoperative IOP (OR = −0.12; 95 % CI -0.22, −0.01; $P = 0.027$).

Table 6 presents the results of comparing postoperative parameters between the FLACS and conventional cataract surgery groups. Consistent with previous findings, the FLACS group revealed significantly less IOL decentration compared with that in the conventional surgery group (0.21 ± 0.13 versus 0.30 ± 0.12, respectively, $P < 0.001$). Glare and halo occurrence after surgery were significantly lower in the FLACS group ($P = 0.021$ and $P < 0.001$). However, no significant differences were observed in UDVA and CDVA between the two groups after surgery. Although the FLACS group demonstrated a 50 % lower proportion of patients with clinically significant IOL decentration (≥0.4 mm) or tilt (≥7°), no statistical significance was observed ($P = 0.161$ and $P = 0.200$, respectively).

4. Discussion

In this study, we investigated preoperative factors affecting IOL tilt and decentration using the anterior *SS*-OCT (CASIA II) after cataract surgery and identified whether FLACS can reduce the risk of IOL instability. After one month of cataract surgery, there was no significant change in IOL tilt compared to baseline, but a slight increase in IOL decentration was observed across the study population. Multivariate analysis revealed that the male sex contributed to the increase in IOL decentration after surgery, consistent with findings

Table 1

Preoperative baseline characteristics of all patients.

Parameters	Mean ± standard deviation			*P*-value
	Total (n = 100)	FLACS (n = 50)	Conventional (n = 50)	
Age (years)	70.36 ± 9.85	67.92 ± 10.81	72.80 ± 8.18	0.125
Sex (male/female)	57/43	26/24	31/19	0.313
Diabetes mellitus, n (%)	21 (21 %)	10 (20 %)	11 (22 %)	0.806
LOCS III Score				
Nuclear	4.29 ± 0.71	4.29 ± 0.83	4.28 ± 0.57	0.944
Cortex	3.03 ± 1.67	3.26 ± 1.52	2.80 ± 1.80	0.170
Posterior subcapsular	2.10 ± 1.96	2.10 ± 2.07	2.10 ± 1.87	>0.999
IOL Master 700				
ACD (mm)	3.08 ± 0.44	3.17 ± 0.44	2.99 ± 0.42	0.051
LT (mm)	4.50 ± 0.46	4.44 ± 0.51	4.56 ± 0.42	0.129
AL (mm)	23.83 ± 1.05	24.02 ± 1.21	23.65 ± 0.81	0.084
CASIA II AS-OCT				
Lens diameter (mm)	9.88 ± 0.76	9.91 ± 0.76	9.86 ± 0.76	0.775
Lens decentration (mm)	0.21 ± 0.13	0.20 ± 0.13	0.22 ± 0.12	0.341
Lens tilt (°)	5.01 ± 1.49	5.17 ± 1.42	4.89 ± 1.56	0.459

FLACS, femtosecond laser-assisted cataract surgery; LOCS, Lens Opacity Classification System; ACD, anterior chamber depth; LT, lens thickness; AL, axial length; AS-OCT, anterior segment optical coherence tomography.

Table 2
Preoperative and postoperative parameters.

Parameters (n = 100)	Baseline (Mean ± SD)	One month Post-surgery (Mean ± SD)	*P*-value
UDVA (LogMAR)	0.58 ± 0.43	0.13 ± 0.15	<0.001
CDVA (LogMAR)	0.51 ± 0.55	0.07 ± 0.15	<0.001
IOP (mmHg)	15.41 ± 2.43	14.71 ± 2.32	0.005
SE (Diopter)	−0.43 ± 1.94	−0.29 ± 0.53	0.535
OPD scan			
Total cylinder	1.05 ± 0.68	1.09 ± 1.04	0.412
Cornea cylinder	0.95 ± 0.79	0.68 ± 0.52	0.001
Internal cylinder	0.98 ± 0.82	1.30 ± 1.23	0.348
CASIA II AS-OCT			
Decentration (mm)	0.21 ± 0.13	0.25 ± 0.13	0.010
Decentration axis (°)	285.5 ± 123.9	345.2 ± 116.8	<0.001
Tilt (°)	5.01 ± 1.49	4.84 ± 1.42	0.355
Tilt axis (°)	284.52 ± 123.45	288.40 ± 108.87	0.786

UDVA, uncorrected distal visual acuity; CDVA, corrected distal visual acuity; IOP, intraocular pressure; SE, spherical equivalent; AS-OCT, anterior segment optical coherence tomography.

Table 3
Univariate regression analysis with regard to postoperative intraocular lens decentration.

Preoperative variables	95 % CI	*P*- value	Preoperative variables	95 % CI	*P*-value
Sex (M:1, F:0)	(0.01, 0.12)	0.018	**OPD scan**		
Age	(-0.01, 0.01)	0.202	Total cylinder (D)	(-0.02, 0.07)	0.237
DM (yes:1, no:0)	(-0.11, 0.02)	0.183	Cornea cylinder (D)	(-0.03, 0.04)	0.829
FLACS (yes:1, no:0)	(-0.15, −0.05)	0.001	Internal cylinder (D)	(-0.02, 0.04)	0.543
			IOL Master 700		
UDVA (LogMAR)	(-0.03, 0.10)	0.264	ACD (mm)	(-0.04, 0.08)	0.602
CDVA (LogMAR)	(-0.03, 0.06)	0.573	LT (mm)	(-0.04, 0.08)	0.490
IOP (mmHg)	(-0.01, 0.01)	0.775	AL (mm)	(-0.03, 0.02)	0.714
SE (D)	(-0.01, 0.03)	0.054	**CASIA II AS-OCT**		
			Lens diameter (mm)	(-0.01, 0.06)	0.180
LOCS III score			Decentration (mm)	(-0.12, 0.31)	0.368
Nuclear	(-0.03, 0.04)	0.774	Decentration axis (°)	(-0.01, 0.01)	0.992
Cortex	(-0.03, 0.01)	0.080	Tilt (°)	(-0.02, 0.02)	0.843
Posterior subcapsular	(-0.01, 0.01)	0.913	Tilt axis (°)	(-0.01, 0.01)	0.206

DM, Diabetes mellitus; FLACS, femtosecond laser-assisted cataract surgery; UDVA, uncorrected distal visual acuity; CDVA, corrected distal visual acuity; IOP, intraocular pressure; SE, spherical equivalent; D, Diopter; LOCS, Lens Opacity Classification System; ACD, anterior chamber depth; LT, lens thickness; AL, axial length; AS-OCT, anterior segment optical coherence tomography.

Table 4
Univariate regression analysis with regard to postoperative intraocular lens tilt.

Preoperative variables	95 % CI	*P*-value	Preoperative variables	95 % CI	*P*-value
Sex (M:1, F:0)	(−0.48, 0.67)	0.739	**OPD scan**		
Age	(−0.03, 0.03)	0.979	Total cylinder (D)	(−0.34, 0.52)	0.673
DM (yes:1, no:0)	(−0.94, 0.45)	0.482	Cornea cylinder (D)	(0.02, 0.73)	0.037
FLACS (yes:1, no:0)	(−0.95, 0.17)	0.173	Internal cylinder (D)	(−0.23, 0.48)	0.490
			IOL Master 700		
UDVA (LogMAR)	(−0.78, 0.59)	0.786	ACD (mm)	(−1.10, 0.20)	0.170
CDVA (LogMAR)	(−0.70, 0.34)	0.490	LT (mm)	(−0.39, 0.86)	0.457
IOP (mmHg)	(−0.26, −0.03)	0.011	AL (mm)	(−0.29, 0.25)	0.892
SE (D)	(-0.06, 0.25)	0.233	**CASIA II AS-OCT**		
			Lens diameter (mm)	(0.21, 0.92)	0.002
LOCS III score			Decentration (mm)	(−2.17, 2.38)	0.929
Nuclear	(−0.32, 0.49)	0.675	Decentration axis (°)	(−0.01, 0.01)	0.200
Cortex	(−0.27, 0.06)	0.220	Tilt (°)	(0.05, 0.43)	0.012
Posterior subcapsular	(−0.21, 0.08)	0.367	Tilt axis (°)	(−0.01, 0.01)	0.606

DM, Diabetes mellitus; FLACS, femtosecond laser-assisted cataract surgery; UDVA, uncorrected distal visual acuity; CDVA, corrected distal visual acuity; IOP, intraocular pressure; SE, spherical equivalent; D, Diopter; LOCS, Lens Opacity Classification System; ACD, anterior chamber depth; LT, lens thickness; AL, axial length; AS-OCT, anterior segment optical coherence tomography.

Table 5
Multivariate regression analysis with regard to postoperative intraocular lens decentration and tilt.

Decentration-related parameters	Odds ratio (95 % CI)	*P*-value	Tilt-related parameters	Odds ratio (95 % CI)	*P*-value
Sex (M:1, F:0)	0.06 (0.01, 0.11)	0.047	**Lens diameter**	0.71 (0.38, 1.05)	<0.001
FLACS (yes:1, no:0)	−0.09 (−0.14, −0.04)	0.001	**Tilt**	0.23 (0.06, 0.40)	0.007
			IOP	−0.12 (−0.22, −0.01)	0.027
			Cylinder (cornea)		0.054

FLACS, femtosecond laser-assisted cataract surgery; IOP, intraocular pressure.

Table 6
Subgroup analysis between the femtosecond laser-assisted cataract and conventional surgery groups.

Parameters	FLACS (n = 50)	Conventional (n = 50)	*P*-value
UDVA (LogMAR)	0.14 ± 0.17	0.16 ± 0.17	0.622
CDVA (LogMAR)	0.08 ± 0.13	0.08 ± 0.16	0.976
SE (D)	−0.19 ± 0.63	−0.28 ± 0.48	0.424
OPD scan			
Total cylinder	0.79 ± 0.85	0.67 ± 0.53	0.434
Cornea cylinder	0.81 ± 0.48	0.61 ± 0.59	0.057
Internal cylinder	0.82 ± 0.99	0.72 ± 0.72	0.569
Questionnaire			
Distance satisfaction	4.04 ± 1.19	3.74 ± 1.30	0.372
Glare	1.26 ± 0.66	1.84 ± 1.16	0.021
Halo	1.15 ± 0.36	1.93 ± 1.03	<0.001
CASIA II AS-OCT			
Decentration (mm)	0.21 ± 0.13	0.30 ± 0.12	<0.001
Decentration axis (°)	85.40 ± 105.52	275.00 ± 114.86	<0.001
Tilt (°)	4.64 ± 1.48	5.03 ± 1.35	0.173
Tilt axis (°)	303.24 ± 96.90	273.54 ± 118.77	0.174
Portion of meaningfully abnormal IOL position			
Decentration ≥0.4 mm	5/50 (10 %)	10/50(20 %)	0.161
Tilt ≥7°	2/50 (4 %)	4/50 (8 %)	0.400

Data indicate the mean ± standard deviation. FLACS, femtosecond laser-assisted cataract surgery; UDVA, uncorrected distal visual acuity; CDVA, corrected distal visual acuity; SE, spherical equivalent; D, Diopter; AS-OCT, anterior segment optical coherence tomography; IOL, intraocular lens.

by Fan et al. [7] In contrast, when patients underwent FLACS, there was a tendency for the degree of IOL decentration to decrease. Theoretically, when the femtosecond laser surgery was performed, it helped reduce complications associated with manual capsulotomies, such as radial tears, as well as facilitated more precise centering and sizing of the capsulotomy. Moreover, since the cataract could be fragmented without causing significant damage to the zonule, the risk of zonular lysis and subclinical zonular damage might be minimized. Thus, our study suggests that FLACS can contribute to enhanced IOL stability after surgery.

According to our study, several factors influence the postoperative IOL tilt. A larger crystalline lens diameter and preoperative lens tilt are associated with higher postoperative IOL tilt. A larger lens diameter may create more space inside the capsular bag, facilitating the free movement of the IOL and leading to increased IOL instability and tilt. Similarly, preoperative tilt establishes a tilted baseline for the position of the capsular bag, influencing postoperative tilt despite successful cataract surgery. Furthermore, a higher preoperative IOP was linked to decreased postoperative IOL tilt. Although it is difficult to interpret the direct relationship between these two factors, the characteristics of the collagen fibers that make up the capsular bag and zonule could potentially explain the relationship. According to certain studies, under conditions of high tensile loading in an in vivo environment, the collagen network undergoes remodeling, resulting in enhanced mechanical durability [22,23]. Nonetheless, additional research is necessary to determine whether elevated IOP within the normal range could enhance zonular stability and, consequently, reduce IOL tilt. The postoperative tilt axis appears to be influenced by the orientation of the haptic [10]. However, the missing information on the direction of the haptic in each surgery could pose a limitation.

In subgroup analysis comparing the FLACS and conventional surgery groups, the degree of postoperative IOL tilt and visual acuity did not significantly differ between the two groups. Despite improved IOL centration observed after FLACS compared to conventional cataract surgery, visual acuity differences were not significant between the two groups. This could be attributed to the small decentration in both groups, which is consistent with previous studies reporting that decentration less than 0.4 mm is not clinically significant [1,18,24]. However, subjective scores, such as postoperative glare and halo, demonstrated better results in the FLACS group. There was no significant difference between the FLACS and conventional surgery groups in postoperative corneal astigmatism (0.81 ± 0.48 vs 0.61 ± 0.59, respectively, P = 0.057) or internal astigmatism (0.82 ± 0.99 vs 0.72 ± 0.72, respectively, P = 0.569), which can affect halo and glare. Although direct evidence linking reduced glare and halo severity to decreased IOL decentration in the FLACS group is lacking, the possibility that the FLACS group's lower postoperative glare and halo were related to IOL decentration cannot be dismissed. Although not statistically significant, the amount of postoperative IOL tilt was lower in the FLACS group. Furthermore, in terms of the proportion of clinically meaningful IOL decentration (≥0.4 mm) or tilt (≥7°), the FLACS group demonstrated improved outcomes in both decentration and tilt; however, these differences did not reach statistical significance. These findings suggest that the use of femtosecond laser in cataract surgeries, especially when employing multifocal IOLs that are particularly more sensitive to IOL decentration and tilt [3,25,26], may significantly improve patient satisfaction. However, glare and halo phenomena are subjective metrics, and patient bias may occur in those who receive FLACS; therefore, these findings should be interpreted with caution. Further research is warranted to investigate this hypothesis thoroughly.

This study had some limitations, including its retrospective design, limited sample size, and a relatively short-term follow-up period. Furthermore, a quantitative evaluation of manual anterior capsulotomy size, circularity, and centering was not performed. However, regarding the follow-up period, we aimed to identify predisposing factors present before surgery, examining patients one month after cataract surgery. Capsular bag shrinkage can influence lens positioning following cataract surgery. Kato et al. reported that capsular bag shrinkage can manifest as early as one month after surgery [27]. Dick et al. found that the capsular bag shrinkage stabilized over three months. When compared with the conventional group, the FLACS group showed less capsular bag shrinkage and fewer changes in postoperative lens position after three months of surgery [28]. These findings suggest the need for further research that incorporates a longer follow-up period to assess the effects of capsular shrinkage and other potential postoperative factors on IOL decentration or tilt after surgery. In addition, future studies should include other factors known to affect IOL decentration and tilt, such as white-to-white corneal diameter, angle κ and α.

5. Conclusions

In conclusion, we identified preoperative factors influencing postoperative IOL tilt and decentration, highlighting a significant reduction in IOL decentration in the FLACS group as a modifiable factor. Additionally, the FLACS group exhibited better postoperative glare and halo scores. These findings lay the groundwork for potential research into whether performing FLACS can enhance patient satisfaction during cataract surgery employing multifocal IOLs, where precise IOL positioning is crucial.

Ethics statement

This retrospective study received approval from the institutional review board of Asan Medical Center, Seoul, South Korea (2023-1466).

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Data availability statement

The data will be made available on request.

CRediT authorship contribution statement

Yunhan Lee: Writing – review & editing, Writing – original draft, Investigation, Formal analysis, Data curation, Conceptualization. **Hoon Il Choi:** Writing – review & editing, Writing – original draft, Investigation, Formal analysis, Data curation, Conceptualization. **Seonha Bae:** Writing – original draft, Investigation, Formal analysis, Data curation. **Ho Seok Chung:** Writing – original draft, Methodology, Investigation, Formal analysis, Data curation. **Jae Yong Kim:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation. **Hun Lee:** Writing – review & editing, Writing – original draft, Validation, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e29780.

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