Clinical outcomes of combined pars plana vitrectomy and scleral fixation of the intraocular lens with a suspension bridge method in eyes with aphakia or insufficient capsular support

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ABSTRACT.

Purpose: To describe a modified technique of scleral fixation for intraocular lens (IOL) implantation and report the clinical outcomes of combined pars plana vitrectomy and scleral IOL fixation using the suspension bridge method.

Methods: This retrospective case series included 57 eyes (56 patients) of aphakia or phakic and pseudophakic eyes with insufficient capsular support that underwent IOL implantation or dislocated IOL repositioning with scleral fixation using the 'suspension bridge' method by a single surgeon between 1 July 2010 and 1 March 2019. Preoperative status, changes in visual acuity, refractive outcomes as spherical equivalent and related complications were assessed with a minimum follow-up of 3 months.

Results: The mean follow-up period was 25.5 ± 25.4 months. Preoperative visual acuity (logarithm of the minimum angle of resolution) was 1.32 ± 0.68 (20/400 Snellen), and it significantly improved to 0.80 ± 0.53 (20/125), 0.59 ± 0.56 (20/80) and 0.24 ± 0.37 (20/35) at 1 week, 1 month and 3 months, respectively (p < 0.001). Postoperative complications included corneal wound dehiscence (n = 1), vitreous incarceration (n = 1), optic-iris capture (n = 6) and cystoid macular oedema (n = 1). The above-mentioned complications were successfully corrected with simple procedures. However, one case of IOL dislocation required reoperation.

Conclusion: The modified technique of the suspension bridge method precludes the need for a scleral flap, with the advantage of easy adjustment of the IOL position. It is a simple and feasible technique with good surgical results and low complication rates.

Key words: intraocular lens implantation – pars plana vitrectomy – scleral fixation – suspension bridge method

Introduction

Cataract surgery is one of the most frequently performed operations globally. During cataract surgery, the crystalline lens is usually replaced with an intraocular lens (IOL) inserted into the capsular bag. However, in some situations, it is necessary to leave the operated eye aphakic or to fixate the IOL in a different manner than to place it inside the capsular bag. Following advances in cataract surgery, surgical aphakia has become uncommon. Secondary IOL implantation is now most commonly performed as part of IOL exchange or repositioning (Asadi & Kheirkhah 2008; Kristianslund et al. 2017a,b).

The debate persists regarding which methods are best for eyes lacking sufficient capsular support (Kim & Kim 2015; Stem et al. 2017). Scleral fixation of a posterior chamber (PC) IOL is a well-established and effective technique for insufficient capsular support due to zonular weakness or capsular bag defect (Hu et al. 1988; Aznabayev et al. 2007; Scharioth et al. 2010). Scleral fixation of a PC IOL may be preferred when a PC IOL is anatomically desired, such as in a patient with a shallow anterior chamber in which an anterior chamber IOL could cause corneal decompensation or when iris anatomy is not amenable to iris fixation of the IOL. Additionally, a

PC IOL is proximate to the ocular rotational axis and the nodal point; therefore, implantation of PC IOLs could result in better optical results (Duffey et al. 1989; Pavlin et al. 1993).

Many surgeons have improved the scleral fixation technique, and various techniques of transscleral suturing of IOL fixation have been introduced (Kokame et al. 2004; Moawad & Ghanem 2012; Agarwal et al. 2013; Liu & Cheng 2013; Stem et al. 2017; Yamane et al. 2017; Aaltonen et al. 2019; Vounotrypidis et al. 2019; Bonnell et al. 2020; Ishikawa et al. 2020). However, many of these techniques require intricate surgical manoeuvres and are associated with an increased risk of surgical trauma. Suture erosion and breakage are associated with the risk of IOL dislocation, which remains a significant concern when using a scleral fixation technique (Vote et al. 2006; Kokame et al. 2018).

In this context, we have developed a modified surgical technique that can achieve stable IOL fixation to the sclera and easily adjust the IOL position with a lower risk of suture exposure. We have named this technique the 'suspension bridge' method because the IOL is suspended between hanger sutures and the strings elongate to near the conjunctival fornix. The purpose of this study is to introduce this suspension bridge method for the scleral fixation of an IOL and to report its clinical outcomes.

Materials and Methods

Patient enrolment

The medical records of patients who underwent scleral fixation of an IOL using the suspension bridge method at Ajou University Hospital, Suwon, South Korea, between 1 July 2010 and 1 March 2019 and who had been followed up for at least 3 months were retrospectively reviewed. This study was conducted in accordance with the Declaration of Helsinki, and the Institutional Review Board of Ajou University Medical Center approved this retrospective review and analysis of patient data (MED-MBD-19-283). The requirement for informed consent was waived because of the retrospective nature of the study.

We included aphakic eyes with inadequate capsular support who underwent scleral fixation of an IOL with the suspension bridge technique. Phakic or pseudophakic eyes with severe zonular instability who underwent removal of their crystalline lens or IOL and scleral fixation of the IOL with this technique were also included. All patients underwent total pars plana vitrectomy (PPV) at the same time as the scleral IOL fixation. Patients with other ocular morbidities that could influence visual acuity, such as corneal opacity, amblyopia, history of retinal detachment or globe injury, retinal vascular disorders involving the macula and macular pathologies including macular degeneration or macular atrophy, were excluded.
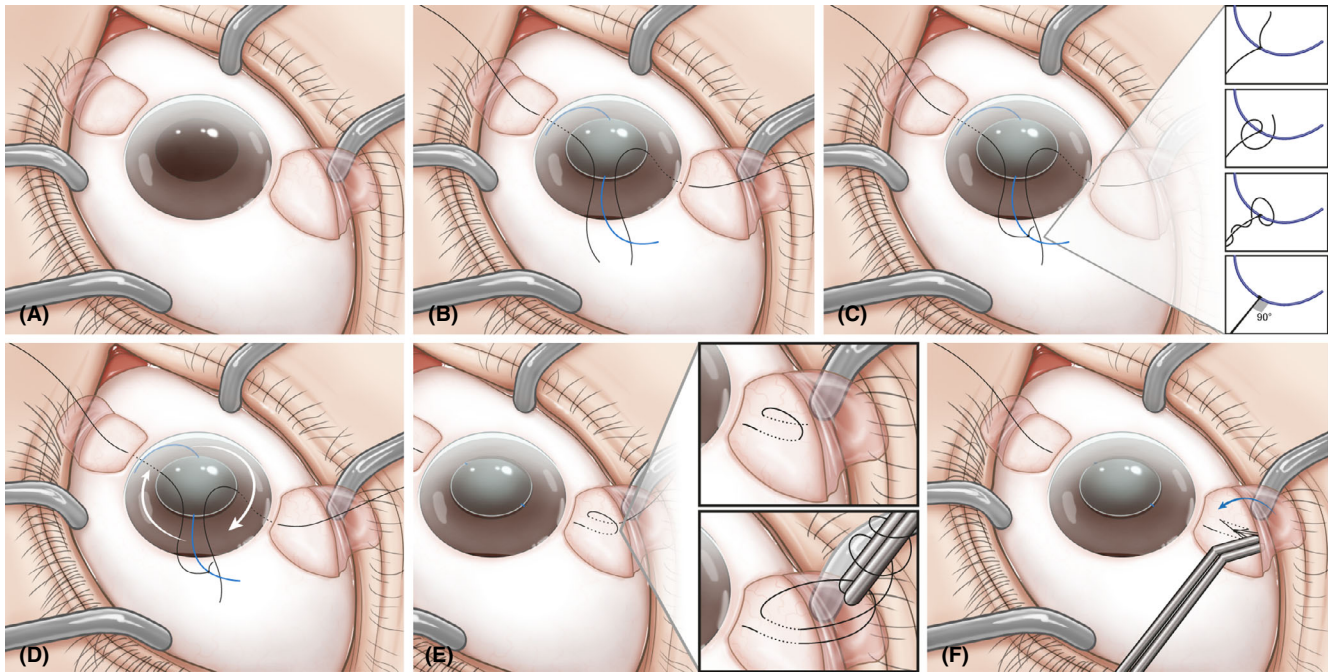
Surgical technique

All surgeries were performed by a single surgeon (J.H.S.). All surgeries were combined with total PPV under general or retrobulbar anaesthesia. Cataract extraction with phacoemulsification was performed for the subluxated crystalline lens. In cases with dislocated IOL, if the IOL had no fault and was reusable, the IOL in situ was repositioned with scleral fixation. If not, the IOL was cut into two pieces in the anterior chamber and extruded from the 2.8-mm limbal clear corneal incision. Two fornix-based conjunctival flaps with snip incisions 2-mm apart from the corneal limbus were made 180° apart (Fig. 1A). After PPV, a Sensar AR40 monofocal 3-piece IOL (Johnson and Johnson Vision, Santa Ana, CA, USA) was loaded into the cartridge, and the leading haptic and optic were inserted into the anterior chamber by the injector through a 2.8-mm bevelled superior clear corneal incision. The trailing haptic was purposely left outside the eye. Two points were marked 2.5 mm (axial length <26 mm) or 3.0 mm (axial length ≥26.0 mm) apart from the corneal limbus symmetrically at the 2 o'clock and 8 o'clock positions, respectively. One end of a double-armed 10-0 polypropylene (Prolene®, Johnson and Johnson, New Brunswick, NJ, USA) suture with two curved needles at each end was passed through the sclera and docked into a 26-gauge needle passed in the same manner from the opposite side. The 26-gauge needle with the 10-0 polypropylene suture was then withdrawn resulting in the 10-0 polypropylene suture bridging the PC. The suture was then externalized through a 2.8-mm superior corneal incision using 25-G endoforceps and cut in the middle (Fig. 1B). A 10-0 polypropylene suture from the 2 o'clock position was securely tied perpendicularly at the trailing haptic, 2.5-mm ahead of the tip (Fig. 1C). To prevent knot slippage, an additional looped nylon suture was tied right next to 10-0 polypropylene knot on the tip side. The trailing haptic was inserted into the anterior chamber, and the IOL was rotated clockwise. Thereafter, the leading haptic was externalized through the corneal incision using 25-G endoforceps (Fig. 1D). A 10-0 polypropylene suture from the 8 o'clock position was tied in the same manner, and the same process was repeated. The IOL was then placed in the PC. The needles of each arm were sutured on the sclera twice near the fornix, and both sides were simultaneously pulled to centre the suspended IOL (Fig. 1E). After tying the knots securely at both ends, the two scleral fixation knots and suture strings were buried under Tenon's capsule and conjunctiva (Fig. 1F). The Tenon and conjunctival peritomy were securely closed with 8-0 polyglactin (Vicryl®; Johnson and Johnson) suture (Video S1). When a more precise centration of the IOL was needed, the IOL position was finely adjusted by properly pulling the suspension sutures on both sides before conjunctival wound closure (Fig. 2).

Ocular examination

Patient records were reviewed, and the following data were collected: age, sex, medical and surgical ocular history, preoperative and postoperative visual acuity, refractive status, intraocular pressure (IOP), keratometry value, and intraoperative and postoperative complications. Data at the preoperative visit and postoperative 3 months were investigated for the statistical analysis. The primary outcome of the study was the changes in visual acuity and IOP at postoperative 3 months. Secondary outcomes were the prediction error in spherical equivalent (SE) and intraoperative or postoperative complications. Operative reports were reviewed for the model and power of the implanted IOL. Based on the power

Fig. 1. Surgical technique of the 'suspension bridge' method. (A) Two fornix-based conjunctival flaps with snip incisions 2-mm apart from the corneal limbus were made 180 degrees apart. (B) After inserting the intraocular lens (IOL) into the anterior chamber using an injector with the trailing haptic left outside, one end of the double-armed 10-0 polypropylene suture was passed through the sclera *ab externo* and docked into a 26-gauge needle passed from the opposite side. The 26-gauge needle and polypropylene suture were withdrawn resulting in the suture bridging the posterior chamber. The suture was then externalized through a corneal incision using 25-G endoforceps and cut in the middle. (C) One end of the 10-0 polypropylene suture was securely tied perpendicularly at the trailing haptic. (D) The IOL was rotated clockwise and the other end of the 10-0 polypropylene suture from the opposite side was tied at the leading haptic in the same manner. (E) After the IOL was placed in the posterior chamber, the needles of each arm were sutured on the sclera twice near the fornix. (F) After tying the knots securely at both ends, the two fixation knots and suture strings were buried under Tenon's capsule and the conjunctiva.
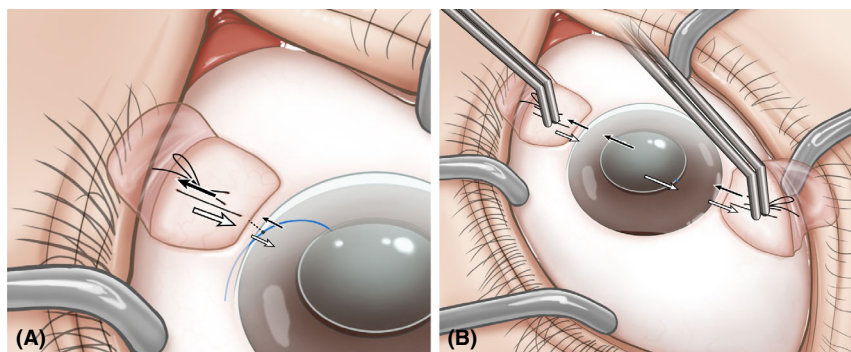
Fig. 2. Fine adjustment of the intraocular lens (IOL) position. (A) The position of the IOL was slightly moved towards (black arrow) or away (white arrow) from the fixation suture site by pulling the sutures on the scleral bed. (B) The IOL position was finely adjusted by properly pulling the suspension sutures on both sides.

of the IOL implanted, the targeted postoperative refraction in SE using in-the-bag calculation was recorded. The SRK/II and SRK/T formulas were utilized for calculating IOL power in all patients. Prediction error was defined as the difference between postoperative refraction and targeted refraction presented as SE (postoperative SE − targeted SE). Absolute prediction error was defined as the absolute value of prediction error (|

postoperative SE − targeted SE|). The mean absolute prediction error was the mean value of absolute prediction error for all patients in whom postoperative refraction was measured. Potential complications consisted of corneal wounds, pupillary IOL capture, postoperative inflammation, suture-related problems, vitreous haemorrhage, endophthalmitis and retinal detachment. Cystoid macular oedema (CME) was defined as new-onset

postoperative oedema that was confirmed with optical coherence tomography (OCT) persisting more than 1 month after surgery. An IOL tilt was clinically evaluated according to the IOL position in relation to the iris plane using slit lamp biomicroscope examination. IOL tilt was diagnosed if the IOL optic was not parallel to the iris plane and one side of the IOL was noticeably closer to the posterior iris than other parts.

Statistical methods

Statistical analysis was performed using SPSS version 25.0 for Windows (IBM Corp., Armonk, NY, USA). Numerical variables are presented as mean ± standard deviation, whereas categorical variables are presented as counts and proportions. Groups were compared using the paired t-test and Wilcoxon signed rank test. Most sample sizes were large enough the central limit theorem applies. A non-parametric test such as the Wilcoxon signed rank test was used in cases where the central limit theorem does not apply. For testing the normality of sample distribution in statistical analysis of SE, the Shapiro–Wilk test was used. The interpretation of the value of Shapiro–Wilk test was as follows; normal (>0.05) or deviated from a normal distribution (<0.05). A p-value of <0.05 was considered statistically significant. Visual acuity in Snellen equivalents was converted to the logarithm of the minimum angle of resolution (logMAR) unit for analysis purposes. In the assessment of refractive outcomes, the prediction error was calculated as the postoperative SE refraction minus the targeted refraction by each IOL formula. Thus, a negative prediction error indicated a more myopic final refraction than that targeted by the IOL formula. The mean absolute prediction error was calculated as the absolute value of the difference between postoperative SE and targeted refraction.

Results

A total of 77 eyes (76 patients) underwent combined PPV and scleral fixation with the suspension bridge method during the study period. Of these, 14 eyes (14 patients) were excluded from the study due to the short follow-up period at the time of analysis. Of the remaining 63 eyes (62 patients) the following cases were excluded: 1 corneal opacity, 2 amblyopia and 3 macular degeneration or macular atrophy. Therefore, 57 eyes (56 patients, 43 male, 77% and 13 female, 23%) who underwent follow-up for a minimum of 3 months were finally included in the analysis. No postoperative complication was reported regarding the 20 eyes (20 patients) excluded from this study until their last follow-up, and their median follow-up duration was 1.03 ± 0.42 (range, 0.25–2) months.

Baseline characteristics are detailed in Table 1. The mean patient age at the time of surgery was 60.40 ± 9.35 (range, 39–77) years, and the mean follow-up duration was 25.5 ± 25.4 (range, 3–95) months. There were 13 aphakic eyes (23%), 13 cases of subluxated crystalline lens (23%), and 31 eyes with dislocated PC IOLs (54%). The mean preoperative logMAR visual acuity was 1.32 ± 0.68 (20/400 Snellen equivalent). All eyes underwent combined PPV with a 23-gauge (36 eyes, 63%) or 25-gauge (21 eyes, 37%) system. Among 31 pseudophakic eyes, the IOL was removed in four cases (13%) and was rescued and repositioned in 27 cases (87%). Pars plana lensectomy with vitreous cutter was performed for six eyes with subluxated crystalline lens (6 of 13). No intraoperative complication was noted.

Preoperative values and postoperative changes in visual acuity and IOP are summarized in Table 2. The mean postoperative logMAR visual acuity after 1 week, 1 month and 3 months was 0.80 ± 0.53, 0.59 ± 0.56 and 0.24 ± 0.37 (20/125, 20/80 and 20/35 Snellen equivalent), respectively. A statistically significant improvement in vision was noted throughout the follow-up period (p-, 95% confidence intervals 0.35–0.70, 0.55–0.91, 0.91–1.25, respectively, paired t-test). No statistically significant difference was found in IOP during the study period.

The postoperative SE error is shown in Table 3. The SE error could be analysed in 28 eyes (28 patients). The prediction error at postoperative 3 months was −0.17 ± 1.08 with the SRK/II formula and 0.10 ± 1.07 with the SRK/T formula. The mean absolute predication error was 0.80 ± 0.71 with the SRK/II formula and 0.76 ± 0.74 with the SRK/T formula. No statistically significant difference was found in prediction error or mean absolute prediction error between the formulas (p = 0.327, p = 0.652, respectively, Wilcoxon signed rank test).

Postoperative complications are summarized in Table 4. Postoperative complications included corneal wound dehiscence in 1 eye (1.8%), vitreous

Table 1. Baseline characteristics of the 56 patients (57 eyes).

Characteristic	
Age at surgery (years)	60.40 ± 9.35 (range, 39–77)
Duration of follow-up (months)	25.5 ± 25.4 (range, 3–95)
Sex (number, %)	
Female	13 (23%)
Male	43 (77%)
Lens status (number, %)	
Aphakic	13 (23%)
Phakic	13 (23%)
Pseudophakic	31 (54%)
Visual acuity (logMAR)	1.32 ± 0.68
Axial length (mm)	23.80 ± 1.28 (range, 21.77–30.69)
Intraocular pressure (mmHg)	15.60 ± 4.32 (range, 9–27)
Trocar gauge used (number, %)	
23 gauge	36 (63%)
25 gauge	21 (37%)

Table 2. Preoperative and postoperative logMAR visual acuity and IOP.

	Baseline	1 week	1 month	3 months
Visual acuity (logMAR)	1.32 ± 0.68	0.80 ± 0.53	0.59 ± 0.56	0.24 ± 0.37
Snellen equivalent	(20/400)	(20/125)	(20/80)	(20/35)
p-Value*		<0.001	<0.001	<0.001
IOP (mmHg)	15.60 ± 4.32	14.39 ± 4.19	14.28 ± 4.08	15.84 ± 5.60
p-Value†		0.068	0.066	0.250

IOP = intraocular pressure, logMAR = logarithm of minimum angle of resolution.
* Compared with preoperative visual acuity.
† Compared with preoperative IOP.

Table 3. Spherical equivalent error by the IOL formula.

	SRK/II	SRK/T	p-Value
Prediction error (D)	-0.17 ± 1.08 (range, −2.41 to 3.12)	0.10 ± 1.07 (range, −2.38 to 3.65)	0.327
Mean absolute predication error (D)	0.80 ± 0.71 (range, 0.06 to 3.12)	0.76 ± 0.74 (range, 0.01 to 3.65)	0.652

D = dioptre, IOL = intraocular lens, SE = spherical equivalent.

Table 4. Postoperative complications.

Complication	N (%)	Mean onset time (months)	Treatment
Wound dehiscence	1 (1.8%)	1	Wound closure
Vitreous 1	YAG	incarceration vitreolysis	1 (1.8%)
Optic-iris capture	6 (10.5%)	6 ± 3 (range: 3 –11)	Pupil dilation and spontaneous repositioning (4 eyes with LPI, 2 eyes without LPI)
IOL tilt	1 (1.8%)	25	Observation
CME	1 (1.8%)	4	Intravitreal bevacizumab injection
IOL dislocation	1 (1.8%)	44	Reoperation

CME = cystoid macular oedema, IOL = intraocular lens, LPI = laser peripheral iridectomy, YAG = yttrium aluminium garnet laser.

incarceration in 1 eye (1.8%), optic-iris capture in 6 eyes (10.5%), CME in 1 eye (1.8%) and IOL tilt in 1 eye (1.8%). Wound dehiscence was treated with wound closure, and vitreous incarceration was treated with yttrium aluminium garnet laser vitreolysis. Optic-iris capture was recovered by a mydriatic agent with or without laser peripheral iridectomy. CME was treated with intravitreal bevacizumab injection. Because the displacement induced only a small amount of astigmatism corrected by glasses, a tilted IOL could be observed without any treatment. One case of IOL dislocation (1.8%) occurred because of suture knot slippage from the superior haptic and the IOL was dislocated into the vitreous cavity with the inferior haptic in place. This case required reoperation. There were no serious complications including suture exposure, retinal detachment, corneal decompensation and endophthalmitis during the follow-up period.

Discussion

Our study showed that combined PPV and scleral fixation of IOL with the suspension bridge technique resulted in good visual and refractive outcomes with an acceptable complication rate, making it an effective option for secondary IOL implantation.

Scleral fixation of PC IOLs can prevent many postoperative complications because the IOLs are located at a more physiologic position and therefore have a lower risk of physical contact with the iris and greater distance from the corneal endothelium than in other procedures such as those involving anterior chamber IOLs and iris-fixated IOLs. Scleral fixation was first introduced by Malbran et al. (1988). In the continuous evolution of techniques for scleral-fixated PC IOL, efforts have been made to reduce the incision size, avoid IOL tilt or decentring, increase suture longevity, and minimize complications.

Recently, a polytetrafluoroethylene 7-0 (Gore-Tex CV-8, WL Gore and Associates, Newark, DE, USA) suture with higher tensile strength has been proposed for various haptic fixation techniques (Bonnell et al. 2020). However, there are several disadvantages with this material due to its thick calibre, and dislocation of IOLs fixed with this material has also been reported. Sutureless intrascleral IOL fixation has been introduced, but it is noteworthy that none of the three-piece IOL haptics is designed for intrascleral placement (Agarwal et al. 2013; Yamane et al. 2017). Therefore, various complications such as haptic erosion through the scleral bed and IOL dislocation have been reported (Wilgucki et al. 2015). Retropupillary fixation of the IOL may be easier to fixate the haptics using the McCannel suture technique or enclave the IOL to the posterior surface of the iris, compared with scleral fixation of the IOL. However, retropupillary iris fixation of the IOL carries the risk of potential complications resulting from the characteristic position of the iris and IOL, including iris chafing, pigment dispersion and progressive peripheral anterior synechia (Kim & Kim 2015). CME has also been a well-recognized complication in eyes with iris-fixated IOLs (Massa et al. 2019).

In our study, we used a foldable three-piece IOL because its haptics are thinner and rounder than those of the single-piece IOL and have a 5-degree posterior angulation; both properties can minimize the risk of iris chafing. A foldable IOL with an injector system for scleral fixation also reduces the operating time and postoperative astigmatism, with the additional advantage of decreased postoperative inflammation and fast visual recovery.

All cases in our study underwent combined PPV. One of the benefits of combined vitrectomy at the time of scleral IOL fixation is that comorbid retinal pathology can be addressed simultaneously for early visual rehabilitation. Release of any vitreoretinal traction is another advantage of combined vitrectomy, lowering the chance of vitreoretinal manipulation during the scleral fixation procedure. In our study, there was no case of retinal detachment, and only one case of vitreous incarceration into the surgical wound occurred. Additionally, with an infusion cannula system, IOP stabilization and maintenance of the anterior chamber allow for a better operation field. The suture needle can also be precisely passed *ab externo* taking advantage of IOP stabilization (Althaus & Sundmacher 1993).

The postoperative complications in this study were consistent with or lower

than those reported by recently published studies of scleral IOL fixation. CME was noted in 1.8% of eyes in our study, and in 2.0%, 1.0% and 1.9% of eyes in previous studies (Kumar et al. 2013; Khan et al. 2016; Yamane et al. 2017). IOL dislocation was noted in 1.8% of eyes in our study, which was much lower than that of previous studies as 6.3% and 3.2% of eyes in previous studies (Bading et al. 2007; Scharioth et al. 2010). IOL tilt was noted in 1.8% of eyes in our study. Postoperative astigmatism resulting from this tilting could be corrected by glasses without any further treatment. In a retrospective study, eyes with the scleral-fixated IOL/PPV ($n = 47$) experienced a 9% rate of lens dislocation (Cho & Yu 2014). A study with a sutureless intrascleral fixation technique reported a 12.5% (3/24) rate of IOL dislocation (Wilgucki et al. 2015).

The incidence of optic-iris capture in our study (10.5%) was also lower than those reported by previous studies. A higher rate of IOL capture (23%) was recorded in a study with scleral-fixated IOL/PPV (Cho & Yu 2014). The original report of a sutureless intrascleral fixation technique with flanges by Yamane et al. reported an optic-iris capture rate of 8.6% (3/35) (Yamane et al. 2014). We speculated that the augmented flow of aqueous humour after PPV in eye movement may increase the risk of reverse iris block and iris capture. Vitrectomy can also induce greater IOL instability due to the loss of vitreous body support in the absence of the capsular bag. Laser peripheral iridectomy (LPI) can force the breakthrough fluid rush of the aqueous humour anteroposteriorly and release the reverse pupillary block. Optic-iris capture did not recur in patients who underwent LPI. Moreover, with experience, the observed complication rates have decreased over time. To minimize the risk of optic-iris capture, the passage of the suture needle through the sclera was made more vertically perpendicular to the sclera, directed to the posterior pole, positioning the IOL slightly more posteriorly. Optic-iris capture was not observed among 17 cases included in our study after 2016.

In our study, the postoperative prediction error showed a trend towards a slight myopic deviation from the target with the SRK/II formula and hyperopic deviation from the target with the SRK/T formula. These two formulas were noninferior to each other when comparing the accuracy of the IOL calculation formulas in determining postoperative refraction in our study. However, definitive conclusions may not be reached without a larger sample size. In a previous study investigating patients who underwent scleral fixation of PC IOL and PPV or anterior vitrectomy, the postoperative prediction error showed a postoperative myopic shift of -1.04 D in PPV group (Cho & Yu 2014). This study was designed as scleral fixation of IOL at 1.5 mm posterior from the limbus which have resulted in more anterior location of IOL in comparison with our study. In our study, we suggest that the IOL was located at in-the-bag position by fixated 2.5 mm posterior from the limbus and finely adjusted the position of the IOL. The scleral sutures for IOL refixation positioned more posterior from the limbus have resulted in postoperative refraction similar to before IOL dislocation (Kristianslund et al. 2017a,b). In a previous study comparing scleral-fixated IOL with retropupillary iris-fixated IOL, there was no statistically significant difference postoperatively in the amount of refractive error between the two groups. However, less refractive stability with significant hyperopic change was noted in the iris-fixated group over 12 months postsurgery (Kim & Kim 2015). The authors postulated that this may be caused by progressive iris stromal thinning and chronological changes in the vitreous body. IOLs fixated to the mobile iris may move more than scleral-fixated IOLs and be displaced towards the synergistic vitreous body.

Suture knots may erode through the conjunctiva following sutured scleral-fixated IOL surgery, and this can be associated with IOL dislocation and infection, as the suture provides a direct avenue for exogenous bacteria to enter the eye (Heilskov et al. 1989; Schechter 1990; Asadi & Kheirkhah 2008). Instead of creating a scleral flap, as in the conventional method, we elongated the suture string to near the conjunctival fornix and made a fixing knot which could finely adjust the position of the IOLs. Our surgical technique can prevent complications associated with creating a scleral flap, and the exposure of fixation knots can also be prevented because Tenon's fascia covering fixation suture knots is much thicker near the conjunctival fornix than at the limbus. Furthermore, the postoperative prediction error in our study showed a good refractive outcome, which was much closer to the target refraction than that reported in a previous study (Cho & Yu 2014), with the IOL fixated at a more posterior position from the limbus (2.5 mm) and the position of the suspended IOL finely adjusted along the long suspension suture strings after making the fixation knot.

This study has some limitations most of which are attributable to its retrospective nature. Particularly, we cannot exclude the possibility of selection bias. For instance, with the increased follow-up loss of patients without any complications, the rate of complications might have been overestimated. There was no reported complication in 14 patients excluded from the study due to the short follow-up period at the time of this analysis; a further six patients were excluded due to other exclusion criteria. Although these 20 patients who were excluded from the study did not show any significant complication during the investigation stage of the study, they may have affected the results. The refractive results according to axial length could also not be compared due to the small sample size. Another shortcoming of this study was its relatively short mean follow-up period. The lack of a comparator group such as one having undergone scleral fixation of an IOL with the traditional scleral flap technique is also a limitation.

Despite these limitations, our study suggests that combined vitrectomy and scleral fixation of a PC IOL with the novel suspension bridge method is a good and safe option for correcting aphakia or IOL dislocation. This method can avert the need for a scleral flap and the complications related to suture fixation, with the advantage of covering suture knots with the thicker Tenon's fascia at the conjunctival fornix. This new method also allows easy adjustment of the IOL position because the surgeon can easily control the tension of the string after creating the fixation knot. Further prospective controlled studies with a larger number

of cases and longer-term follow-up are required to fully evaluate the safety and effectiveness of this modified method.

Data availability statement

The data that support the findings of this study are available in the supplementary material of this article.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Video S1. Scleral fixation of the intraocular lens with a modified technique of Suspension Bridge Method.