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ORIGINAL RESEARCH

Cataract Outcomes Following Scleral Buckle Surgery for Retinal Detachment

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Purpose: To investigate refractive, visual, and safety outcomes of cataract surgery performed after scleral buckling (SB) for retinal detachment (RD).

Patients and methods: A chart review at an academic medical center identified eyes with history of SB followed by subsequent cataract extraction between 2010 and 2022. Eyes with less than 3 weeks follow-up, silicone oil at time of biometry measurement, previous cornea surgery, or co-existing pathology impacting refractive outcomes were excluded. Predicted postoperative spherical equivalents (SE) were calculated with the Barrett Universal II (BU2), Kane, and SRK/T formulas for the implanted intraocular lens (IOL), and complications occurring within 1 year of surgery were abstracted.

Results: Sixty eyes of 60 patients met criteria for inclusion, and 40 (66.7%) had postoperative refraction recorded. Absolute prediction errors were 0.49, 0.45, and 0.52D with BU2, Kane, and SRK/T, respectively. Actual postoperative refraction was within 0.5 and 1.0 D of predicted in 26 (65.0%) and 36 (90.0%) using BU2, 23 (58%) and 37 (93%) using Kane, and 21 (52.5%) and 36 (90.0%) using SRK/T. In eyes with macula-on RD, corrected distance visual acuity (CDVA) of logMAR 0.301 (≈20/40) and logMAR 0.544 (≈20/70) or better was achieved in 12 (75.0%) and 15 (93.8%) of eyes. For macula-off RD eyes, these proportions were 19 (63.3%) and 24 (80.0%), respectively. Posterior capsular opacification requiring Nd: YAG capsulotomy was the most frequent complication in 30 (56.7%) eyes.

Conclusion: Refractive outcomes of cataract surgery following SB may be modestly reduced, even when using modern formulas. Nevertheless, cataract surgery in this population results in favorable visual outcomes.

Plain Language Summary: The retina is the part of the eye that is responsible for converting incoming light into a signal that the brain can interpret. A retinal detachment is an emergent condition in which the retina is torn away from its normal position. Scleral buckling is one method of surgically reattaching the retina. Although quite successful, scleral buckling can cause changes to the shape of the eye, and also increases the risk of opacification of the natural lens of the eye, otherwise known as a cataract. The purpose of this study is to investigate the outcomes of cataract surgery in eyes with prior scleral buckle surgery. The results show that despite advancements in methods of measuring the shape of the eye, calculating the appropriately powered IOL to implant, and surgical technique, cataract surgery in eyes with prior scleral buckling may result in poorer outcomes compared to eyes with no history of scleral buckling.

Keywords: Barrett Universal II, cataract surgery, refractive outcomes, SRK/T, scleral buckle, retinal detachment

Introduction

Retinal detachment (RD) is an emergent concern that requires immediate surgery. Scleral buckle (SB) surgery still remains a viable option, especially in cases of uncomplicated or medium complexity rhegmatogenous retinal detachment (RRD), retinal dialysis, and no posterior vitreous detachment (PVD).[1,2] It is well documented that scleral buckling is associated with changes in biometric variables of the eye, most notably axial length elongation and induced astigmatism,

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due to the compression of the eye circumferentially.[3,4] These changes may influence subsequent ophthalmic procedures like cataract surgery.

In 1988, Smiddy et al reported on the outcomes of 31 eyes that underwent extracapsular cataract extraction following SB.[5] This landmark paper found that vision outcomes and complication rates were favorable. However, there was no assessment of refractive predictability, and technology in axial length and keratometry measurement has since changed. In addition, there has been a significant evolution of intraocular lens (IOL) power calculation formula accuracy since that time. Last, most eyes in this previous study had cataract removal by "lens expression", whereas today nearly all eyes undergo phacoemulsification. Over 30 years later, Smiddy's study remains as one of the largest and most comprehensive evaluations of cataract surgery outcomes in the setting of prior scleral buckling. An updated evaluation of outcomes in this population is warranted.

The purpose of this study was to evaluate refractive, visual acuity, and safety outcomes of cataract surgery performed sequentially after scleral buckling, both with and without vitrectomy, for macula-on and macula-off retinal detachment. We hypothesized that, despite evolutions in biometry, IOL power calculation formulas, and surgical techniques, eyes with a history of SB for retinal detachment would have outcomes that differ from those obtained in eyes without such pertinent history.

Methods

This study received approval from the Penn State College of Medicine Institutional Review Board/Ethics Committee and was carried out in compliance with the Declaration of Helsinki. There was no informed consent due to the retrospective nature of the study, however the data was coded and maintained in compliance with the IRB Data Management Plan and all HIPAA regulations regarding patient records were followed.

This was a single-center, retrospective consecutive case series including eyes that had history of SB for retinal detachment, cataract surgery at the Penn State Eye Center between 2010 and 2022, and biometric measurements taken with the IOLMaster 700 SS-OCT optical biometer, IOLMaster 5, or immersion ultrasound. Eyes were excluded from data abstraction and analysis for lack of a postoperative refraction greater than 3 weeks following cataract surgery, presence of silicone oil in the eye at the time of biometric measurements, clinical variables unable to be extracted from the electronic medical record, history of prior incisional cornea surgery, presence of other co-existing ocular pathology known to affect the refractive/visual outcome (ie keratoconus, severe primary open angle glaucoma, and pseudo-exfoliation), or incidence of complication during cataract surgery (ie posterior capsule tear). Eyes with postoperative corrected distance visual acuity (CDVA) worse than 20/70 were excluded from refractive outcomes analysis.

Demographic information including age, race, and ethnicity were collected for all patients. The following were abstracted for each eye: co-existing ocular pathology/surgical history, date of scleral buckling, CDVA 3–12 months after scleral buckling, potential acuity meter, method of axial length measurement, method of keratometry measurement, biometric measurements of the study and fellow eyes, time interval between scleral buckling and cataract surgery, implanted IOL model and power, and intraoperative observations and complications. Postoperative data collected included total length of follow-up following cataract surgery, manifest refraction performed 21–360 days after cataract surgery, uncorrected distance visual acuity (UDVA) and CDVA measured 21–180 days after cataract surgery, and complications within 1 year of cataract surgery.

For each eye, the predicted postoperative spherical equivalent was calculated using the Barrett Universal II (BU2) and Kane (available at https://iolcalculator.escrs.org), as well as SRK/T formulas for the implanted intraocular lens. The lens constants for each IOL model were the ones immediately available on the online calculator. For eyes measured by the IOLMaster 5 or immersion ultrasound, where measurement of lens thickness (LT) was not possible, these optional parameters were omitted from the calculation. The SRK/T formula was included as it is independent of the anterior chamber depth (ACD) as an input variable, which may be impacted by SB surgery. It is also known to perform relatively well in axial myopes, which is typical of eyes with a history of retinal detachment. For refractive and visual outcomes, the eyes were stratified into eyes that underwent SB and those that underwent combined SB and pars plana vitrectomy (PPV).

Descriptive statistics including mean and standard deviation were used to enumerate the demographics of the study population. For comparisons between the study and contralateral fellow eyes from the same patient, the normality of the data was first tested using a Kolmogorov-Smirnov test. Given the non-normal distribution of the data, a Wilcoxon signed-rank test was used to compare biometric measurements of study eyes and fellow surgery-naïve eyes. For comparisons between BU2, Kane, and SRK/T refractive outcomes, p-values were calculated using the heteroscedastic method with Holm correction (R v4.2.2; Rand Wilcox "Rallfun-v41" package) to compare refractive outcomes between the formulas.[6]

Results

Preoperative Features

A total of 60 eyes from 60 patients met criteria for inclusion in the study. The mean age of included patients at the time of scleral buckling was 54.44 ± 13.27 years (range 13–79 years). Forty eyes (66.7%) were from male patients, and 20 (33.3%) eyes were from females. Thirty-two (53.3%) eyes were right eyes, and 28 (46.7%) eyes were left eyes. Regarding the racial composition of the study group, 49 (81.7%) patients identified as White, 3 (5.0%) patients identified as Asian, 3 (5.0%) patients identified as Black or African American, 3 (5.0%) patients identified as belonging to two or more races, and 2 (3.3%) patients identified as other.

SB surgery was performed with vitrectomy in 38 (63.3%) eyes and without vitrectomy in the remaining 22 (36.7%). Within these groups, there were multiple risk factors for retinal detachment identified: 34 (56.7%) had myopia, 19 (31.7%) had lattice degeneration, 11 (18.3%) had retinal tears, and 10 (16.7%) had trauma. These eyes also had history of concomitant retinal disease including 8 (13.3%) with non-proliferative diabetic retinopathy, 5 (8.3%) with vitreous hemorrhage, 4 (6.7%) each with macular hole or epiretinal membrane, 3 (5.0%) with macular edema, 2 (3.3%) with proliferative diabetic retinopathy, and 1 (1.7%) each with retinal ischemia or retinal hemorrhage. Of the 40 [SB = 14; SB + PPV = 26] eyes for which CDVA following scleral buckling was available, 3 (7.5%) [SB = 2 (14.2%); SB + PPV = 1 (3.8%)], 6 (15.0%) [SB = 4 (28.6%); SB + PPV = 2 (7.69%)], and 12 (30.0%) [SB = 7 (50.0%); SB + PPV = 5 (19.2%)] had a visual acuity of logMAR 0.301 (≈20/40), 0.544 (≈20/70), or 1 (≈20/200) or better, respectively.

Axial length (AL) was measured using optical biometry [either partial coherence interferometry (PCI; IOLMaster 5, Carl Zeiss Meditec, Jena, Germany) or swept-source optical coherence tomography (SS-OCT; IOLMaster 700, Carl Zeiss Meditec, Jena, Germany) in 50 (83.3%) eyes and A-scan ultrasound in 10 (16.7%) eyes. Keratometry measurements were obtained using automated hand-held keratometry (KM 500, Nidek Marco, Gamagori, Japan) in 5 (8.3%) eyes and automated reflectance keratometry (IOLMaster 5 or 700, Carl Zeiss Meditec, Jena, Germany) in 55 (91.7%) eyes. Post SB biometry values for study eyes and contralateral fellow eyes are enumerated in Table 1. The average AL of the study eye was 0.67 mm longer than that of the unoperated fellow eye from the same subject, which was statistically significant

Table 1 Biometric Measurements of Study Eyes and Fellow Surgery-Naïve Eyes

	Mean ± SD		*P* value
	Study Eye	Fellow Eye	
AL, mm	26.59 ± 1.87	25.92 ± 1.90	*<0.001
K1, mm	43.06 ± 1.74	42.63 ± 5.34	0.021
K2, mm	44.73 ± 1.92	44.31 ± 1.67	*<0.001
Average K, mm	43.87 ± 1.78	43.76 ± 1.64	0.034
ACD, mm	3.42 ± 0.33	3.60 ± 0.43	*<0.001
LT, mm	4.39 ± 0.41	4.16 ± 0.86	0.002
WTW, mm	12.26 ± 0.47	12.21 ± 0.46	0.075
ACD/AL Ratio	0.13 ± 0.01	0.14 ± 0.02	*<0.001

Note: *Statistical significance, p<0.05.
Abbreviations: AL, axial length; K1, flat keratometry; K2, steep keratometry; K, keratometry; ACD, anterior chamber depth; LT, lens thickness; WTW, white-to-white.

($p < 0.001$). The average ACD of the study eye was 0.18 mm shallower than that of the fellow eye from the same subject, which was also statistically significant ($p < 0.001$). The mean ACD/AL ratio in scleral buckled and contralateral surgery-naïve eyes was 0.13 ± 0.01 and 0.14 ± 0.02, respectively ($p < 0.001$).

Operative Features

The mean interval between SB and cataract surgery was 17.9 ± 25.8 months (range 2 to 135 months). Cataract surgery was performed by phacoemulsification for all 60 eyes. There were no combination procedures done to treat other ocular pathology. The average age at the time of cataract surgery was 56.0 ± 13.3 years. Fourteen different IOL models were implanted in study eyes: 23 (38.3%) SN60WF (AcrySof, Alcon, Fort Worth, TX, USA), 16 (26.7%) MX60E (enVista, Bausch + Lomb, Ontario, Canada), 5 (8.3%) MA60AC (AcrySof, Alcon, Fort Worth, TX, USA), 4 (6.7%) MA60MA (AcrySof, Alcon, Fort Worth, TX, USA), 4 (6.7%) MX60 (enVista, Bausch + Lomb, Ontario, Canada), 4 (6.7%) SN6ATx (AcrySof, Alcon, Fort Worth, TX, USA), and 1 (1.7%) each CC60WF (Clareon, Alcon, Fort Worth, TC, USA), DFT415 (AcrySof, Alcon, Fort Worth, TX, USA), DIU150 (Tecnis, Johnson and Johnson Vision, Irvine, CA), and ZCB00 (Tecnis, Johnson and Johnson Vision, Irvine, CA, USA). The mean power of the implanted IOL was 13.0 ± 5.7 D (range −3.0 to 21.5) [SB = 11.8 ± 6.2; SB + PPV = 4.0 ± 4.9].

Postoperative Features

Postoperative refractions were available on 40 (66.7%) of the 60 eyes (Figure 1). The mean and absolute prediction errors for the BU2, SRK/T and Kane formulas were −0.05 ± 0.68 D and 0.49 D, −0.02 ± 0.71 D and 0.52 D, and −0.04 ± 0.60 D and 0.45 D, respectively (Table 2). There was a trend toward improved predictability of refractive outcomes with BU2 and Kane over SRK/T (Figure 2A–2C), with regard to proportion of eyes within 0.50 D of predicted, but these observations were not statistically significant ($p = 0.547$).

Postoperative visual acuities were available on 40 (66.7%) [SB = 14; SB + PPV = 26] of the 60 eyes. Postoperative CDVA ranged from logMAR 0 (≈ 20/20-3) to 0.544 (≈20/70-1), with a median of 0.097 (≈ 20/25-1). Twenty-nine (72.5%) [SB = 8 (57.1%); SB + PPV = 21 (80.8%)] and 40 (100.0%) [SB = 14 (100.0%); SB + PPV = 26 (100.0%)] eyes achieved logMAR 0.301 (≈20/40) and 0.544 (≈20/70) CDVA or better, respectively. Among 16 (40.0%) eyes presenting

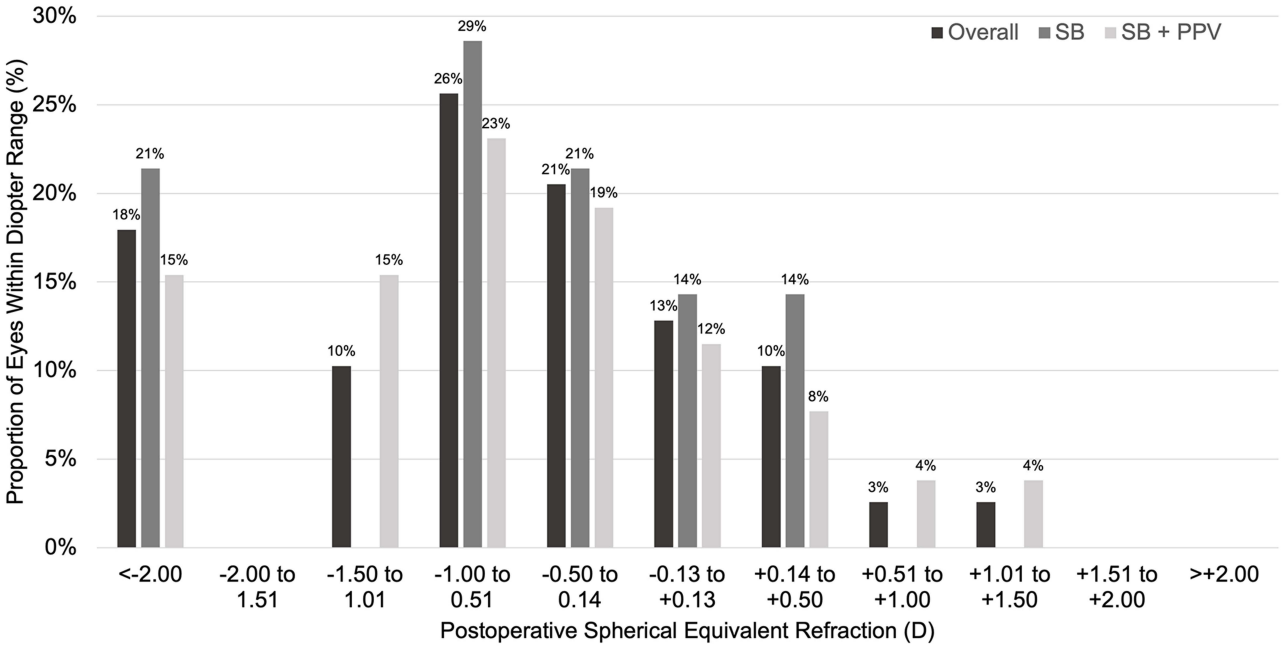

Figure 1 Refractive outcomes after cataract extraction in eyes with history of scleral buckle.
Abbreviations: SB, scleral buckle, only; SB + PPV, scleral buckle and pars plana vitrectomy; D, diopters.

Table 2 Refractive Outcomes of Scleral Buckle Eyes with and without Vitrectomy Using Barrett Universal II, SRK/T, and Kane

	BU2			SRK/T			Kane			P values
	SB	SB + PPV	Overall	SB	SB + PPV	Overall	SB	SB+PPV	Overall	(Overall)
MPE ± SD	0.01 ± 0.71	−0.08 ± 0.68	−0.05 ± 0.68	0.04 ± 0.69	−0.06 ± 0.73	−0.02 ± 0.71	0.04 ± 0.50	−0.09 ± 0.65	−0.04 ± 0.60	0.845
MAE	0.51	0.48	0.49	0.51	0.53	0.52	0.43	0.47	0.45	0.424
medAE	0.43	0.32	0.41	0.53	0.42	0.47	0.51	0.29	0.34	0.769
% within 0.25 D	29%	38%	35%	43%	35%	38%	29%	42%	38%	1.000
% within 0.50 D	64%	65%	65%	43%	58%	53%	50%	62%	58%	0.547
% within 0.75 D	79%	81%	80%	71%	69%	70%	93%	77%	83%	0.392
% within 1.00 D	93%	88%	90%	93%	88%	90%	100%	88%	93%	1.000

Abbreviations: BU2, Barrett Universal II; MAE, mean absolute error; medAE, median absolute error; MPE, mean prediction error; PPV, pars plana vitrectomy; SB, scleral buckle.

with macula-on retinal detachment, CDVA was better than logMAR 0.301 (≈20/40) and 0.544 (≈20/70) in 7 (43.8%) and 16 (100.0%) of eyes, respectively. Among 24 (60.0%) eyes with macula-off retinal detachment, CDVA was better than logMAR 0.301 (≈20/40) in 24 (100.0%) of eyes.

The mean length of follow-up from the date of cataract surgery to last follow-up was 38.1 ± 35.8 months (range 2.6 to 134.3 months). There was follow-up of 12 months in 17 (28.0%) eyes. Postoperative complications within 1 year of cataract surgery occurred in 40 (67.0%) eyes (Table 3). The most prevalent complications following cataract surgery were posterior capsular opacification (PCO) requiring YAG laser capsulotomy in 34 (56.7%) eyes at mean onset of 3.1 months, cloudy and wavy vision in 4 (6.7%) eyes, and cystoid macular edema in 3 (5.0%) eyes. One (1.7%) eye had recurrent retinal detachment 1.4 weeks after surgery. This eye underwent cataract surgery 4.3 months following scleral buckling and was noted to have high intraocular pressure and mobile capsular bag complex during surgery. One (1.7%) eye required Ozurdex implantation 3.8 months following cataract surgery due to extensive epiretinal membrane causing macular edema. One (1.7%) eye experienced new-onset HSV keratitis 1 month following surgery.

Discussion

Scleral buckling continues to be a useful and widely practiced technique for RRD repair, particularly in cases involving phakic lens status, high myopia, absence of a PVD, retinal dialysis, and young patients.[7] This study reports on the preoperative, perioperative, and postoperative features and outcomes of cataract surgery following SB. To the best of our knowledge, this is the largest study to date that investigates outcomes of cataract surgery following SB for retinal detachment. Unlike the excellent study by Smiddy et al from 1988, our cohort of patients all received phacoemulsification and most had measurements obtained using automated optical biometry, instead of ultrasound.[5] In 1988, the Holladay and SRK/T formulas had not been published yet.[8,9] Today, we benefit from having formulas like Barrett Universal II, which is known for working better than either of the aforementioned formulas in eyes with axial myopia.[10]

It is well-established that SB surgery is associated with axial length elongation and decreased anterior chamber depth.[1,11,12] However, it is not well reported how this surgery impacts the ACD/AL ratio. In the present study, we compared the 60 study eyes status-post SB with their contralateral counterparts. If we assume that two surgery naïve eyes from the same patient are similar, we can infer the paired differences in ACD/AL ratio is significantly different from zero. While axial myopia is typically associated with increased ACD, the changes induced by SB surgery appear to be in the opposite direction (increased axial myopia and decreased ACD depth). These non-physiologic perturbations may impact IOL lens power calculation formulas' ability to accurately predict effective lens position.

The mean prediction error of the BU2 formula in our cohort was close to zero (−0.05 D). On the other hand, the SD around this prediction error (0.69 D) was more than twice that reported by Melles in his cohort of more than 13,000 surgery naïve eyes (0.31 D). Our mean absolute error (0.49 D) was also higher than that reported by Melles in surgery naïve eyes (0.31 D). It is possible that the lens constants on iolcon.org used to calculate the BU2 predictions for the

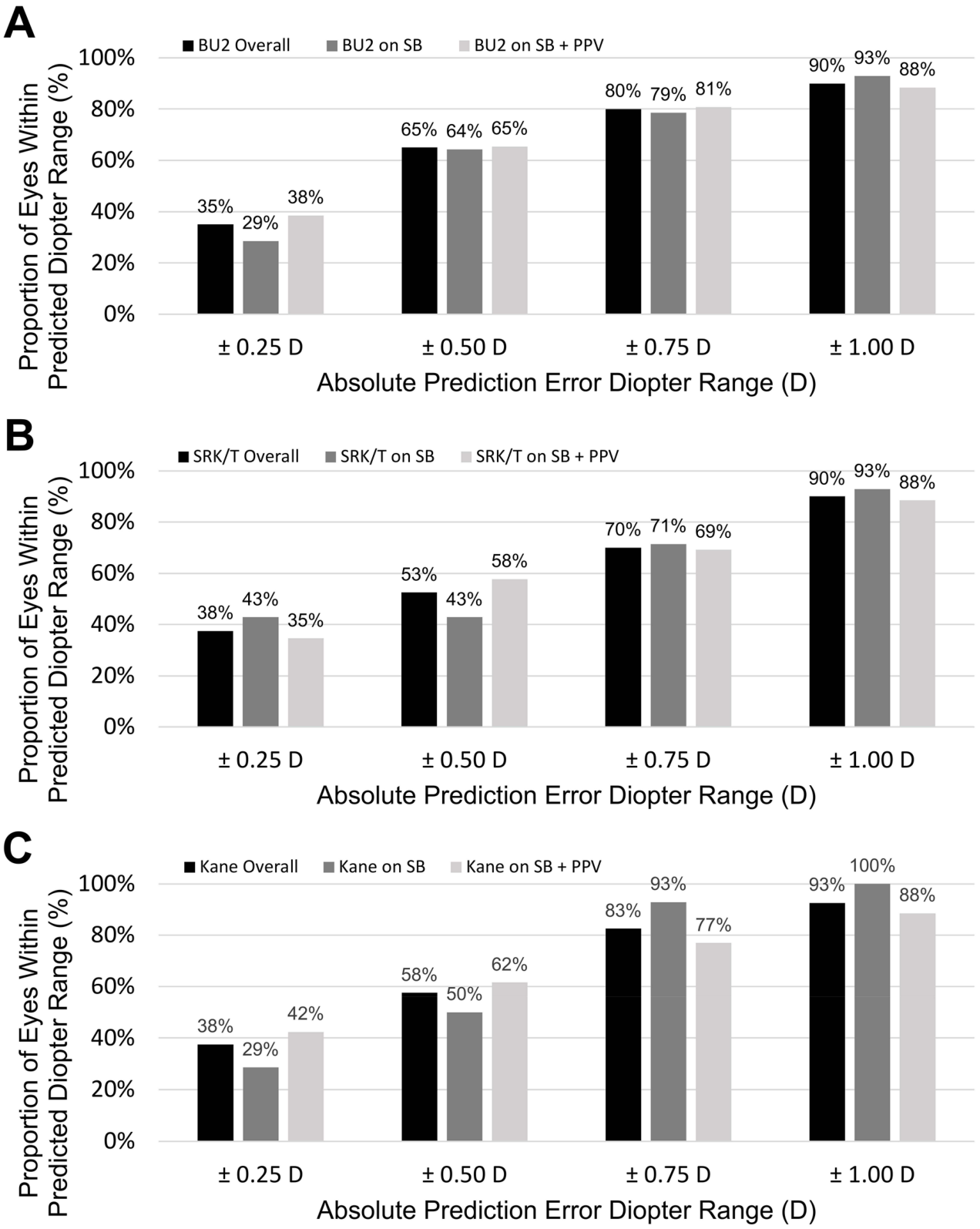

Figure 2 Proportion of eyes with an absolute prediction error between 0.25, 0.5, 0.75, and 1.0 D of predicted spherical equivalent (SE) refraction using (**A**) Barrett Universal II, (**B**) SRK/T, and (**C**) Kane formulas.
Abbreviations: SB, scleral buckle, only; SB + PPV, scleral buckle and pars plana vitrectomy; D, diopters.

Table 3 Postoperative Complications Presenting Within 1 Year Following Cataract Extraction

Complication Following Cataract Surgery	Incidence, N (%)	Mean Onset, Months
Posterior capsular opacification requiring YAG	34 (56.7)	3.1
Vision cloudy and wavy	4 (6.7)	1.0
Cystoid Macular Edema	3 (5.0)	2.0
Repeat YAG	2 (3.3)	5.0
Elevated IOP	2 (3.3)	5.0
Intermittent Itching	2 (3.3)	0.8
Trace IRF fluid on OCT	2 (3.3)	4.1
Recurrent RD	1 (1.7)	0.3
Intermittent sharp pain	1 (1.9)	2.1
Optic Nerve Cupping	1 (1.9)	2.1
Ozurdex Implantation	1 (1.7)	3.8
Burning and Tearing after gtt Insertion	1 (1.7)	1.5
Rebound Inflammation	1 (1.7)	1.5
Intermittent Sharp Pain	1 (1.7)	2.1
Increased Photophobia	1 (1.7)	0.7
HSV keratitis (primary episode)	1 (1.7)	1.0
HSV keratitis (flare)	1 (1.7)	5.6
Distortion	1 (1.7)	0.7
Corneal Ulcer	1 (1.7)	3.9

Abbreviations: ACD, anterior chamber depth; AL, axial length; YAG, yttrium aluminum garnet laser; IOP, intraocular pressure; IRF, intraretinal fluid; OCT, optical coherence tomography; RD, retinal detachment; gtt, eyedrop; HSV, herpes simplex virus.

present study, are not well optimized for use in eyes with prior SB. Although BU2 has been found to perform better than other formulas in eyes with concomitant PPV and cataract surgery,[13] it is possible that the changes in the ACD/AL ratio identified in the present study perturb the effective lens position calculation for the BU2 formula in an unnatural way, thereby making the formula's predictions less accurate. Finally, the increased variability could be related to our inclusion of eyes with less than logMAR 0.301 (≈20/40) CDVA, which would have an inherently more ambiguous refractive endpoint. Nevertheless, these eyes experienced favorable refractive outcomes that are only modestly reduced compared with what we might expect in surgery naïve eyes (78–80%)[10] and on par with what would be expected in a cohort of post-myopic LASIK eyes (65–70% within 0.50 D).[14]

Our study reports favorable visual acuity outcomes, as 63% of eyes regained visual acuity of logMAR 0.301 (≈20/40) or better. This is similar to that reported by Ruiz et al (52%),[15] Kerrison et al (72%),[16] Smiddy et al (84%),[5] and Eshete et al (85%).[17] Kerrison et al reported preoperative CDVA between logMAR 0.301 (≈20/40) and 1.301 (≈20/400) in 85% of eyes and worse than logMAR 1.301 (≈20/400) in 15% eyes,[16] which is favorable compared to our cohort where 66% of eyes had preoperative CDVA between logMAR 0.301 (≈20/40) and 1.301 (≈20/400) and 34% of eyes had CDVA worse than logMAR 1.301 (≈20/400). One plausible explanation for our post SB and post-cataract extraction outcomes being on the lower end compared to other studies is because our cohort began with worse pre-SB CDVA and there was a higher proportion of eyes with macula-off retinal detachment in our study compared to macula-on retinal detachment.

Ursell et al[18] found that the incidence of Nd: YAG capsulotomy for PCO ranged between 2% and 13% at 3 years and 6–19% at 5 years post-cataract surgery. Kerrison et al[16] reported a prevalence for visually significant PCO of 27% in eyes with a history of scleral buckling that underwent subsequent cataract surgery. In the present study, we identified a prevalence of PCO requiring YAG at 57% within 1 year of cataract surgery. It is important to note that the PCO requiring YAG may not be directly related to the scleral buckling, but instead to the coincident occurrence of vitrectomy in a large proportion of these patients. In fact, Jun et al noted a more rapid progression of PCO in eyes undergoing sequential cataract surgery and pars plana vitrectomy compared to those undergoing cataract surgery alone.[19]

Limitations of this study include its retrospective nature, relatively small sample size, heterogeneity in the IOL models implanted, and heterogeneity in the lane length used to perform refractions in our clinic. Prior to 2019, many of the refractions were done in an 8-foot exam lane. This might have resulted in recorded refractions that were approximately 0.25 D hyperopic relative to the targeted spherical equivalent. Nevertheless, we believe this to be the largest, most comprehensive report on cataract outcomes in the post SB population. This analysis may be particularly helpful to surgeons when choosing a refractive target in this population, especially in the era of modern vergence formulas like BU2.

Data Sharing Statement

Data supporting the results can be obtained upon request to the corresponding author.

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Disclosure

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