• Clinical Research •

Impact of macular status on intraocular lens power estimation in proliferative diabetic retinopathy eyes undergoing phacovitrectomy

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Abstract

● **AIM:** To assess the refractive outcomes and effect of the macular status in eyes with proliferative diabetic retinopathy (PDR) and significant vitreous hemorrhage received with combined phacoemulsification and pars plana vitrectomy (phacovitrectomy).

● **METHODS:** This retrospective case-control study recruited 176 eyes, including 86 PDR eyes with severe vitreous hemorrhage, who received phacovitrectomy with intraocular lens implantation, and 90 eyes who underwent phacoemulsification only for cataracts (control group). Postoperative follow-up visits documented best-corrected visual acuity (BCVA) and refractive outcomes at each examination. Postoperative refractive outcomes were quantified as spherical equivalents. The primary outcome measure was the refractive prediction error (PE). The PE and absolute prediction error (AE) were employed as key metrics. Additionally, the number and percentage of patients achieving refractions within ±0.25 diopters (D), ±0.50 D, ±0.75 D, ±1.00 D, and ±2.00 D of the target refractive outcome were documented.

● **RESULTS:** The overall mean age was 64.4±10.5y. There were 98 (55.7%) female and 78 (44.3%) male patients. In the PDR eyes with the phacovitrectomy surgery, mean PE (-0.008±0.872 D) and AE (0.662±0.563 D) by ultrasound biometry showed no statistically significant differences as compared to the control group (PE: 0.117±0.621 D, P=0.277; AE: 0.506±0.375 D, P=0.118). Subgroup analysis showed that the PE was significantly different in eyes with macular thickening (-0.471±0.955 D) compared to those without macular thickening (0.161±0.781 D, P=0.002). The PE was negatively correlated with macular thickening in multivariate model analysis [β=-0.568, 95% confidence interval: -0.987 to -0.150, P=0.008].

● **CONCLUSION:** Combined phacovitrectomy for PDR with severe vitreous hemorrhage exhibits no ultrasound biometry discrepancies as compared to those received phacoemulsification alone. However, the patients with macular thickening show a noticeable myopic shift.

● **KEYWORDS:** intraocular lens power; pars plana vitrectomy; phacoemulsification; proliferative diabetic retinopathy; vitreous hemorrhage

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INTRODUCTION

Diabetes mellitus continuously poses threats to individual health and the medical system. Diabetic retinopathy (DR) is a serious complication of diabetes that affects the microvasculature of the retina, potentially resulting in irreversible vision loss and blindness, particularly in adults of working age[1-4]. Proliferative diabetic retinopathy (PDR), a more advanced form of DR, frequently leads to severe vitreous hemorrhage, which requires vitrectomy surgery as a treatment option. The combination of phacoemulsification and pars plana vitrectomy, known as phacovitrectomy, is becoming more popular due to its ability to decrease the number of surgeries required and lessen the strain on medical resources[5-8]. With the enhancement in the anatomical outcomes, phacovitrectomy is now focused on minimizing the refractive errors to optimize the visual function postoperatively. Due to the dense vitreous opacity, surgeons must rely on ultrasound biometry measurement to predict and calculate the diopter strength of the intraocular lens (IOL) required for implantation during the surgical procedure. Compared to phacoemulsification alone, there are still specific concerns regarding the accuracy of postoperative IOL power in phacovitrectomy surgery, especially when ultrasound is used for the ocular biometric parameter measurements[9-11]. Notably, axial length measurement in diabetic maculopathy is more challenging[12] as the speed of ultrasound could change when it is transmitted through the blood-opaque vitreous body, thereby interfering with the accuracy of axial length measurement.

Currently, there is still no report investigating the accuracy of IOL power by ultrasound biometry measurement in patients who received phacovitrectomy for PDR with severe vitreous hemorrhage. It has been reported that B-scan ultrasonography is an effective strategy to evaluate the macular thickness when optical coherence tomography (OCT) is rendered unfeasible due to dense vitreous hemorrhage[13]. No study has evaluated the correlation of the IOL prediction error (PE) with the macular thickening measurement by B-scan ultrasonography. Herein, we aimed to evaluate the accuracy of IOL power estimation using ultrasound biometry in PDR patients undergoing phacovitrectomy for vitreous hemorrhage, compared to those undergoing phacoemulsification alone, and to explore the potential impact of macular status on IOL power estimation accuracy.

PARTICIPANTS AND METHODS

Ethical Approval Approval for the study protocol was granted by the Ethics Committee for Human Medical Research at the Joint Shantou International Eye Center of Shantou University and the Chinese University of Hong Kong [approval number: EC 20210709(5)-P10]. This approval aligns with the principles outlined in the Declaration of Helsinki. The Ethics Committee has approved the exemption of writing consent from patients as it was a retrospective study. The anonymization of any personal information was sufficiently guaranteed throughout the study.

Participants and Ophthalmic Examinations The medical records of patients with PDR coexisting with severe vitreous hemorrhage, treated from January 2020 to December 2023, were reviewed. Severe vitreous hemorrhage is characterized by conditions in which only the optic nerve head is visible upon examination or when the fundus is entirely obscured, rendering it inaccessible during the ophthalmic assessment. Patients with PDR and significant vitreous hemorrhage requiring phacovitrectomy were included, all of whom underwent surgery performed by a single surgeon. Exclusion criteria comprised neovascular glaucoma, IOL displacement or tilt, other retinal degenerative or vascular diseases, previous trauma, vitreous loss, tractional retinal detachment, or uveitis. This study also included cataract patients without PDR or other retinal diseases who underwent standard phacoemulsification and IOL implantation as controls. All patients in the control group received the same surgical procedure (phacoemulsification and IOL implantation) and had no evidence of retinal pathology. Surgeries for both groups were performed by the same surgeon during the same study period. In all cases, ultrasound biometry was utilized to predict the power of the IOL.

The axial lengths of all patients were measured using the A-scan ultrasound (Aviso, Quantel Medical, France; and SK-3000A, Chongqing Sunkingdom Medical, China) before the surgical procedures. Following instillation of topical anesthetic (0.5% proparacaine eye drop, Alcaine), contact A-scan biometry was performed. The probe was gently placed on the central cornea with minimal pressure to avoid corneal compression and ensure accurate alignment with the visual axis. Velocity parameters were set at 1550 m/s for axial length, 1532 m/s for anterior chamber depth, and 1641 m/s for lens thickness, in accordance with standard velocity assumptions for each respective ocular component. Ten A-scan readings were obtained for each eye. Outliers were identified based on visual inspection and deviation from the central tendency. At least six readings with a within-eye standard deviation (SD) <0.1 mm were retained for analysis, and the final measurement for each parameter was calculated as the average of these remaining values. The IOL power was determined utilizing the SRK/T formula due to its accuracy across axial lengths. This calculation utilized the A-constant as recommended by the manufacturer. The macular thickness in patients undergoing phacovitrectomy was assessed preoperatively using B-scan ultrasonography. The examination utilized a 10 MHz ultrasound probe, and the procedure was performed with the patient in a supine position. The probe was placed on the patient's eyelids, and images were captured from multiple angles to ensure a comprehensive evaluation. When a protrusion in the macular region extending into the vitreous cavity is observed, macular thickening is documented. Two independent observers, blinded to the clinical context, evaluated the B-scan images. In cases of disagreement, a final arbitrator made the definitive judgment.

Phacovitrectomy Surgery A single vitreoretinal surgeon conducted all phacovitrectomy procedures. Standard phacoemulsification through a 2.8-mm corneal incision, followed by posterior chamber IOL implantation, was performed in all cases. For the patients who received

Table 1 Demographics and baseline clinical data of participants *n* or mean±SD

Characteristics	Phacovitrectomy (*n*=86)	Phacoemulsification alone (*n*=90)	*P*
Age, y	58.08±7.61	70.50±9.22	<0.001[b]
Sex			
Female	47	51	0.788[a]
Male	39	39	
Axial length (mm, ultrasound)	22.98±0.86	23.58±1.32	<0.001[b]
Average keratometry value (D)	44.10±1.46	44.16±1.45	0.787[b]
Preoperative BCVA (logMAR)	1.88±0.38	1.03±0.78	<0.001[b]

[a]Chi-square test; [b]Independent *t*-test. SD: Standard devistion; D: Diopters; BCVA: Best-corrected visual acuity; logMAR: Logarithm of the minimum angle of resolution.

phacovitrectomy, vitrectomy was performed after phacoemulsification. All surgeries were performed using the Carl Zeiss LUMERA 700 surgical microscope with the RESIGHT 700 non-contact wide-angle viewing system. The CONSTELLATION® Vision System (Alcon, Fort Worth, TX, USA) was employed for both phacoemulsification and vitrectomy. In each case, a monofocal, aspheric, hydrophobic IOL was implanted.

Vitreoretinal procedures included a 23/25-gauge pars plana vitrectomy, removal of fibrovascular membranes, and pan-retinal laser photocoagulation. After completing the vitreoretinal surgical procedures, air-fluid exchange was conducted, resulting in the retention of air and fluid within the vitreous cavity.

Demographic data, surgical procedures, and clinical outcomes for all study patients were extracted from the medical records. Postoperative follow-up visits documented best-corrected visual acuity (BCVA) and refractive outcomes at each examination. All postoperative refractions were initially measured using an autorefractor, followed by manifest refraction to optimize the correction. The actual postoperative refraction was defined as the refractive result corresponding to the best-recorded BCVA measured during the postoperative period from 1 to 6mo. Postoperative refractive outcomes were quantified as spherical equivalents. The primary outcome measure was the refractive PE, calculated by subtracting the predicted refraction from the actual postoperative refraction. The PE and absolute prediction error (AE) were employed as key metrics. Additionally, we documented the number and percentage of patients achieving refractions within ±0.25 diopters (D), ±0.50 D, ±0.75D, ±1.00D, and ±2.00 D of the target refractive outcome.

Statistical Analysis Statistical analysis was conducted using IBM SPSS Statistics (version 27; SPSS Inc., Chicago, IL, USA) and R software (version 4.3.2; R Foundation for Statistical Computing) within the RStudio integrated development environment (version 2023.12.0; RStudio PBC). BCVA was reported using the logarithm of the minimum angle of resolution (logMAR) scale. Continuous variables were displayed as mean±SD for normally distributed data and median with interquartile range (IQR) for skewed data. Comparative analyses were performed on the two groups using the independent *t*-test for normally distributed continuous variables and the Mann-Whitney *U* test for non-normally distributed continuous variables. Categorical variables were summarized as frequencies and percentages, with the Chi-square test utilized to compare proportions between the two groups. Multiple linear regression analysis was applied to evaluate the strength of the correlation between PE and various clinical characteristics. A significance level of *P* value less than 0.05 was deemed statistically significant.

RESULTS

In total, 86 eyes of 86 patients received phacovitrectomy, and 90 eyes of 90 patients received phacoemulsification only. The overall mean age was 64.4±10.5y. There were 98 (55.7%) female and 78 (44.3%) male patients. Macular thickening was detected by B-scan ultrasonography in 23 (26.7%) patients of the phacovitrectomy group. The two observers showed substantial agreement in applying this consistent criterion, with a Cohen's kappa of 0.77 [95% confidence interval (CI): 0.62–0.92]. Patients in the phacovitrectomy group were significantly younger (58.08±7.61y) compared to the control group (70.50±9.22y, *P*<0.001; Table 1). Moreover, the patients in the phacovitrectomy group (22.98±0.86 mm) had significantly lower axial length than the control group (23.58±1.32 mm, *P*<0.001).

The average PE in the phacovitrectomy group (-0.008±0.872 D, range: -2.980 to 2.630 D) did not exhibit statistically significant variances when compared to the phacoemulsification only group (0.117±0.621 D, range: -1.370 to 1.785 D; *P*=0.277; Table 2). The median AE in the phacovitrectomy group [0.557 (0.221, 0.935) D, range: 0.01 to 2.980 D] also demonstrated no significant difference when compared to the phacoemulsification-only group [0.450 (0.198, 0.785) D, range: 0 to 1.785 D; *P*=0.118]. After adjusting for the confounding factors (age, axial length, average keratometry,

Table 2 Postoperative refractive outcomes of participants *n* (%) or mean±SD or median (IQR)

Refractive outcomes	Phacovitrectomy (*n*=86)	Phacoemulsification alone (*n*=90)	*P*
Postoperative BCVA (logMAR)	0.44±0.35	0.09±0.10	<0.001[b]
Predicted refraction (D)	-0.633±0.460	-0.558±0.301	0.200[b]
Achieved postoperative refraction (D)	-0.642±0.934	-0.442±0.668	0.106[b]
Prediction error (D)	-0.008±0.872	0.117±0.621	0.277[b]
Within ±0.25 D	25 (29.07)	25 (27.78)	0.849[a]
Within ±0.50 D	41 (47.70)	54 (60.00)	0.101[a]
Within ±0.75 D	54 (62.79)	67 (74.44)	0.095[a]
Within ±1.00 D	66 (76.70)	79 (87.80)	0.056[a]
Within ±2.00 D	84 (97.70)	90 (100)	0.237[a]
Median absolute prediction error (D)	0.557 (0.221, 0.935)	0.450 (0.198, 0.785)	0.118[c]
Mean absolute prediction error (D)	0.662±0.563	0.506±0.375	

[a]Chi-square test; [b]Independent *t*-test; [c]Mann-Whitney *U* test. SD: Standard deviation; IQR: Interquartile range; BCVA: Best-corrected visual acuity; logMAR: Logarithm of the minimum angle of resolution; D: Diopters.

Table 3 Postoperative refractive outcomes of participants with or without macular thickening *n* (%) or mean±SD or median (IQR)

Refractive outcomes	With macular thickening (*n*=23)	Without macular thickening (*n*=63)	*P*
Prediction error (D)	-0.471±0.955	0.161±0.781	0.002[b]
Within±0.25 D	5 (21.73)	20 (31.75)	0.366[a]
Within±0.50 D	8 (34.78)	33 (52.38)	0.148[a]
Within±0.75 D	12 (52.17)	41 (65.08)	0.276[a]
Within±1.00 D	17 (73.91)	49 (77.78)	0.707[a]
Within±2.00 D	22 (95.65)	62 (98.41)	0.466[a]
Median absolute prediction error (D)	0.665 (0.415, 1.033)	0.45 (0.210, 0.910)	0.213[c]
Mean absolute prediction error (D)	0.810±0.677	0.607±0.511	

[a]Chi-square test; [b]Independent *t*-test; [c]Mann-Whitney *U* test. SD: Standard deviation; IQR: Interquartile range; D: Diopters.

and preoperative BCVA), the multivariate analysis still showed no significant differences in PE (P=0.537) and AE (P=0.162) between the PDR group and the control group. To further evaluate the performance of the SRK/T formula, we also calculated IOL power using the Kane formula *via* its online calculator. The results demonstrated no statistically significant difference in the median AE between the two formulas [0.557 (0.221, 0.935) D for SRK/T formula *vs* 0.558 (0.262, 0.906) D for Kane formula, P=0.244].

In the phacovitrectomy group, the proportions of eyes achieving a PE within all evaluated intervals (±0.25, ±0.5, ±0.75, ±1.00, and ±2.00 D) showed no significant differences compared to the phacoemulsification-only group (all P>0.05). Among all cases, the majority of eyes showed PE within ±2.00 D. However, two cases exhibited absolute errors exceeding ±2.00 D, specifically +2.63 D and -2.98 D. Case 1 (error +2.63 D) had a lens thickness of 5.11 mm and an anterior chamber depth of 2.71 mm, with a preoperative visual acuity of hand motion. Case 2 (error -2.98 D) had a steep mean corneal curvature of 47.94 D and an axial length of 22.04 mm, along with macular thickening identified on preoperative B-scan ultrasonography.

Subgroup analysis revealed that the PE in the eyes with macular thickening (-0.471±0.955 D) showed a significantly myopic shift compared to those without macular thickening (0.161±0.781 D, P=0.002; Table 3). Nevertheless, no significant differences in AE were observed between the subgroups (P=0.213). There were also no significant differences in the proportions of PE within all evaluated intervals (all P>0.05) between the patients with and without macular thickening.

Multiple linear regression analysis further analyzed the possible risk factors for PE, and we found that PE was negatively correlated with macular thickening (β=-0.568, 95% CI: -0.987 to -0.150, P=0.008; Table 4).

DISCUSSION

Results from this study demonstrated that the patients with PDR and severe vitreous hemorrhage who received combined phacovitrectomy showed comparable ultrasound refractive outcomes to those who received phacoemulsification alone. Previous studies have explored the postoperative refractive errors following combined phacovitrectomy in patients with rhegmatogenous retinal detachment or vitreomacular interface diseases[14-17]. In this study, all patients who received the phacovitrectomy surgery were diagnosed as PDR with severe vitreous hemorrhage. Our findings suggested that the presence

Table 4 Multiple linear regression on the clinical factors associated with prediction error

Variables included in the model	β	95%CI	P
Age (y)	0.005	-0.019 to 0.028	0.705
Preoperative BCVA (logMAR)	-0.054	-0.534 to 0.426	0.823
Average keratometry value (D)	-0.092	-0.219 to 0.034	0.151
Macular thickening	-0.568	-0.987 to -0.150	0.008

The model's adjusted R^2 was 0.086. The variance inflation factors for all independent variables were exceedingly low (age: 1.000, preoperative BCVA: 1.019, average keratometry value: 1.055, macular thickening: 1.073). BCVA: Best-corrected visual acuity; CI: Confident interval; logMAR: Logarithm of the minimum angle of resolution; D: Diopters.

of vitreous hemorrhage did not markedly affect the accuracy of ultrasonographic predictions concerning the postoperative refractive outcomes.

Precise axial length measurement is crucial for preventing substantial postoperative refractive errors. Ultrasound biometry measures the distance between the anterior corneal surface and the internal limiting membrane, while optical biometry assesses the distance from the anterior surface of the cornea to the retinal pigment epithelium. Optical biometry has been recommended for achieving more accurate axial length measurements, especially in patients with macular diseases[10,12,18-19]. In this study, the performance of optical measurements was precluded due to severe vitreous hemorrhage. Consequently, exploring the refractive accuracy utilizing ultrasound biometry under these conditions would be better.

In the phacovitrectomy group, the PE within ±0.5 D was found in 47.7% of the patients, and the PE within ±1.0 D was found in 76.7%. Our results aligned with the refractive error outcomes following phacovitrectomy surgery in previous research that the PE within ±0.5 D was found in 43.2%–53.0% of the patients and the PE within ±1.0 D was found in 75.8%–84.1% of the patients[18,20-21].

A study reported that the B-scan ultrasonography identified macular thickening with a high degree of sensitivity (91%) and specificity (96%) in 77 eyes with strong agreement between ultrasonography and fluorescein angiography findings (kappa=0.80)[13]. The ultrasonographic measurements are correlated with the OCT measurements for both central macular thickness and volume. In this study, OCT examination could not be performed before the operation because of the severe vitreous hemorrhage. Instead, we applied B-ultrasound biometry to evaluate the macular thickness. We found that the patients with macular thickening showed a significant myopic shift as compared to the eyes without macular thickening (Table 3). The thickened retina likely impacts the accuracy of essential ultrasound biometry in measuring the axial length of the eyes. A previous study indicated no notable variation in axial length measurements between optical and ultrasonic methods in normal eyes. However, in eyes with diabetic macular edema, a significantly shorter axial length was detected using ultrasound[12]. The myopic shift observed following phacovitrectomy for treating epiretinal membranes could be attributable to the inaccurate IOL power calculations[22]. This discrepancy has been linked to the underestimation of axial length due to the increased macular thickness observed in these patients. Adjusting the axial length measurement by incorporating the macular thickness obtained from the OCT into the ultrasonographic axial length measurement has been recommended.

A study comparing the refractive results of phacovitrectomy and sequential surgeries in patients with rhegmatogenous retinal detachment found no statistically significant differences in the AE among the macula-on subgroups[14]. Instead, a statistically significant difference was noted in the macula-off subgroups, with subgroup analysis showing that the difference in the AE between the phacovitrectomy group and sequential surgeries group was significantly different in the macula-off ultrasound biometry patients. Consistently, our study showed similar results in the PDR with severe vitreous hemorrhage. The subjects with macular thickening exhibited a significant myopic shift as assessed by ultrasound biometry.

In this study, patients who underwent phacovitrectomy surgery received an air tamponade, absorbed over approximately 1wk. Our study revealed that postoperative refractive PE was not influenced by the air tamponade in eyes with PDR that underwent phacovitrectomy. These findings are consistent with previous research on phacovitrectomy[9,23-24]. Previous studies have indicated that factors such as prolonged duration of diabetes, suboptimal glycemic control, and rapid reductions in blood glucose levels may influence refractive outcomes[25-26]. These systemic factors are believed to affect refractive accuracy predominantly through alterations in lens hydration and transparency. However, it is important to note that all patients in our study underwent phacoemulsification with removal of the crystalline lens. This surgical intervention likely diminishes the potential influence of systemic metabolic variables on the final refractive status.

Due to the retrospective nature of the study and the fact that the A-scan device used in our institution is equipped with the SRK/T formula by default, we opted to use this formula for IOL power calculation. The device does not have newer-generation formulas such as Barrett Universal II or Haigis built-in. Previous studies reported a small but insignificant improvement in the AE when comparing the refractive outcomes derived from the Haigis formula to those predicted by the SRK/T and Holladay formulas, even in the eyes with longer axial lengths[24]. It has been indicated that the average keratometry readings significantly influence the precision of the SRK/T formula[27]. The mean average keratometry value of the patients in this study was 44.13±1.45 D, and no statistically significant difference was observed between the patients who received phacovitrectomy and those who received phacoemulsification alone. It has been reported that formulas such as Olsen and Barrett Universal II may offer better performance in eyes with longer axial lengths[28-29]. However, only 6 patients (3.41%) in our study had axial lengths exceeding 26 mm, which limited the applicability of these newer formulas in our analysis. In addition, we compared the results obtained using the SRK/T formula with those derived from the Kane formula, which is accurate across a wide range of axial lengths[30-31]. No significant difference was observed between the two formulas, further supporting the validity of using SRK/T for the final comparison in our study.

This study has several limitations. First, its retrospective design introduces inherent constraints. Although measures were taken to minimize bias, complete blinding of observers could not be achieved. Significant baseline differences between the groups—attributable to distinct surgical indications—posed challenges for statistical adjustment and limited full control of confounding variables. In this context, the control group primarily serves as a benchmark for the surgeon's contemporaneous performance, and the observed refractive comparability with this reference offers preliminary clinical reassurance. However, definitive conclusions await validation through prospective controlled studies. Second, the assessment of macular thickening relied on qualitative B-scan ultrasonography, which carries inherent subjectivity despite the use of standardized criteria and good inter-observer agreement (kappa=0.77). The unavailability of preoperative OCT data precluded quantitative macular thickness evaluation. Future prospective studies should incorporate OCT-based measurements and postoperative axial length assessment after vitreous clearing to verify these findings and enable exploration of potential axial length correction strategies. Third, the sample size was limited particularly in the macular thickening subgroup. Additionally, patients with severe PDR involving extensive traction were excluded due to the absence of IOL implantation, which may restrict the generalizability of our findings to more advanced cases. Finally, the worse baseline visual acuity in the combined surgery group may have influenced subjective refraction assessments. Nonetheless, this study provides the first analysis of refractive outcomes in patients undergoing phacovitrectomy for PDR with severe vitreous hemorrhage, with minimized variability owing to consistent surgical technique by a single surgeon and standardized postoperative refraction assessment.

This study revealed that combined phacovitrectomy for eyes with PDR and severe vitreous hemorrhage showed no ultrasound biometry discrepancies as compared to those received phacoemulsification alone. However, the patients with macular thickening showed a noticeable myopic shift.

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Data Availability Statement: The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

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REFERENCES

1 Teo ZL, Tham YC, Yu M, *et al*. Global prevalence of diabetic retinopathy and projection of burden through 2045: systematic review and meta-analysis. *Ophthalmology* 2021;128(11):1580-1591.

2 Vision Loss Expert Group of the Global Burden of Disease Study, GBD 2019 Blindness and Vision Impairment Collaborators. Global estimates on the number of people blind or visually impaired by diabetic retinopathy: a meta-analysis from 2000 to 2020. *Eye (Lond)* 2024;38(11):2047-2057.

3 Chia MA, Taylor JR, Stuart KV, *et al*. Prevalence of diabetic retinopathy in indigenous and non-indigenous australians a systematic review and meta-analysis. *Ophthalmology* 2023;130(1):56-67.

4 Liang YH, Zhang XY, Mei W, *et al*. Predicting vision-threatening diabetic retinopathy in patients with type 2 diabetes mellitus: Systematic review, meta-analysis, and prospective validation study. *J Glob Health* 2024;14:04192.

5 Kokame GT, Tanji TT, Yanagihara RT, *et al*. Refractive outcomes of combined cataract surgery and vitrectomy compared to cataract surgery alone. *Ophthalmologica* 2023;246(1):39-47.

6 Port AD, Nolan JG, Siegel NH, *et al*. Combined phaco-vitrectomy provides lower costs and greater area under the curve vision gains than

sequential vitrectomy and phacoemulsification. *Graefes Arch Clin Exp Ophthalmol* 2021;259(1):45-52.

7 Day AC, Donachie PHJ, Sparrow JM, *et al*. United Kingdom national ophthalmology database study of cataract surgery: report 3: pseudophakic retinal detachment. *Ophthalmology* 2016;123(8):1711-1715.

8 Daud F, Daud K, Popovic MM, *et al*. Combined versus sequential pars Plana vitrectomy and phacoemulsification for macular hole and epiretinal membrane a systematic review and meta-analysis. *Ophthalmol Retina* 2023;7(8):721-731.

9 Mayer-Xanthaki CF, Hirnschall N, Gabriel M, *et al*. Influence of combined phacovitrectomy without tamponade on intraocular lens displacement and postoperative refraction. *Acta Ophthalmol* 2022;100(7):e1518-e1521.

10 Miele A, Fumagalli C, Abbruzzese G, *et al*. Biometric refractive error after cataract and retina surgery: a systematic review and a benchmark proposal. *Eye* (*Lond*) 2021;35(11):3049-3055.

11 Sato T, Korehisa H, Shibata S, *et al*. Prospective comparison of intraocular lens dynamics and refractive error between phacovitrectomy and phacoemulsification alone. *Ophthalmol Retina* 2020;4(7):700-707.

12 Attas-Fox L, Zadok D, Gerber Y, *et al*. Axial length measurement in eyes with diabetic macular edema. *Ophthalmology* 2007;114(8): 1499-1504.

13 Lai JC, Stinnett SS, Jaffe GJ. B-scan ultrasonography for the detection of macular thickening. *Am J Ophthalmol* 2003;136(1):55-61.

14 Moussa G, Sachdev A, Mohite AA, *et al*. Assessing refractive outcomes and accuracy of biometry in phacovitrectomy and sequential operations in patients with retinal detachment compared with routine cataract surgery. *Retina* 2021;41(8):1605-1611.

15 Sakamoto M, Yoshida I, Sodeno T, *et al*. Postoperative refractive prediction error measured by optical and acoustic biometry after phacovitrectomy for rhegmatogenous retinal detachment without macular involvement. *J Ophthalmol* 2019;2019:5964127.

16 Liu BS, Cui WN, Niu R, *et al*. Refractive outcomes after vitrectomy combined with phacoemulsification of idiopathic macular holes. *Int J Ophthalmol* 2021;14(2):250-254.

17 Chen X, Zhao H, Ren JY, *et al*. Axial length, vitreoretinal pathology, and anterior chamber depth can predict postoperative refractive outcomes in phacovitrectomy/silicone oil removal. *Int J Ophthalmol* 2023;16(4):554-562.

18 Rahman R, Bong CX, Stephenson J. Accuracy of intraocular lens power estimation in eyes having phacovitrectomy for rhegmatogenous retinal detachment. *Retina* 2014;34(7):1415-1420.

19 Sun HJ, Choi KS. Improving intraocular lens power prediction in combined phacoemulsification and vitrectomy in eyes with macular oedema. *Acta Ophthalmol* 2011;89(6):575-578.

20 Tranos PG, Allan B, Balidis M, *et al*. Comparison of postoperative refractive outcome in eyes undergoing combined phacovitrectomy vs cataract surgery following vitrectomy. *Graefes Arch Clin Exp Ophthalmol* 2020;258(5):987-993.

21 Kang EC, Lee KH, Koh HJ. Comparison of refractive error in phacovitrectomy for epiretinal membrane using ultrasound and partial coherence interferometry. *Eur J Ophthalmol* 2016;26(4):356-360.

22 Kovács I, Ferencz M, Nemes J, *et al*. Intraocular lens power calculation for combined cataract surgery, vitrectomy and peeling of epiretinal membranes for macular oedema. *Acta Ophthalmol Scand* 2007;85(1):88-91.

23 Jeoung JW, Chung H, Yu HG. Factors influencing refractive outcomes after combined phacoemulsification and pars Plana vitrectomy: results of a prospective study. *J Cataract Refract Surg* 2007;33(1):108-114.

24 Manvikar SR, Allen D, Steel DHW. Optical biometry in combined phacovitrectomy. *J Cataract Refract Surg* 2009;35(1):64-69.

25 Kaštelan S, Gverović-Antunica A, Pelčić G, *et al*. Refractive changes associated with diabetes mellitus. *Semin Ophthalmol* 2018;33(7-8): 838-845.

26 Rozema JJ, Khan A, Atchison DA. Modelling ocular ageing in adults with well-controlled type I diabetes. *Adv Ophthalmol Pract Res* 2022;2(2):100048.

27 Reitblat O, Levy A, Kleinmann G, *et al*. Intraocular lens power calculation for eyes with high and low average keratometry readings: comparison between various formulas. *J Cataract Refract Surg* 2017;43(9):1149-1156.

28 Kane JX, Van Heerden A, Atik A, *et al*. Intraocular lens power formula accuracy: comparison of 7 formulas. *J Cataract Refract Surg* 2016;42(10):1490-1500.

29 Melles RB, Holladay JT, Chang WJ. Accuracy of intraocular lens calculation formulas. *Ophthalmology* 2018;125(2):169-178.

30 Darcy K, Gunn D, Tavassoli S, *et al*. Assessment of the accuracy of new and updated intraocular lens power calculation formulas in 10930 eyes from the UK National Health Service. *J Cataract Refract Surg* 2020;46(1):2-7.

31 Pereira A, Popovic MM, Ahmed Y, *et al*. A comparative analysis of 12 intraocular lens power formulas. *Int Ophthalmol* 2021;41(12):4137-4150.