

ACCURACY OF IOL CALCULATIONS USING ULTRASONIC BIOMETRY BASED ON THE FELLOW EYE FOR PHACOVITRECTOMY IN PATIENTS WITH MACULA-OFF RHEGMATOGENOUS RETINAL DETACHMENT

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ABSTRACT

Background: Macula-off rhegmatogenous retinal detachment (RRD) can distort axial-length measurement and reduce the accuracy of intraocular lens (IOL) power calculation before phacovitrectomy.

Objective: To determine the refractive accuracy of fellow-eye ultrasonic biometry compared with affected-eye biometry for IOL calculation in patients undergoing phacovitrectomy for macula-off RRD.

Methods: This prospective diagnostic accuracy study included 71 patients treated at LRBT Eye Hospital, Township, Lahore, from 18 February to 17 June 2026. Axial length and keratometry were recorded in both eyes, and IOL power was calculated with the SRK/T formula. Postoperative prediction error and mean absolute prediction error (MAE) were compared between fellow-eye and same-eye calculations.

Results: Mean age was 52.8±10.7 years and 62.0% were male. Affected-eye axial length was shorter than fellow-eye axial length (23.31±0.91 vs 23.66±0.88 mm; p<0.001). Fellow-eye calculations produced a lower MAE than same-eye calculations (0.67±0.53 vs 1.09±0.77 D; p<0.001). Absolute prediction error was within ±0.50 D in 54.9% versus 31.0% (p=0.004) and within ±1.00 D in 83.1% versus 60.6% (p=0.003), respectively.

Conclusion: Fellow-eye ultrasonic biometry provided better refractive prediction than affected-eye biometry in selected patients with macula-off RRD and may be a practical alternative when affected-eye axial-length measurements are unreliable.

KEYWORDS: Rhegmatogenous retinal detachment; Phacovitrectomy; Intraocular lens; Biometry; Axial length

INTRODUCTION

Rhegmatogenous retinal detachment (RRD) is an ophthalmic emergency caused by separation of the neurosensory retina from the retinal pigment epithelium after liquefied vitreous passes through a retinal break. Its incidence increases with age and is associated with myopia, previous cataract surgery, ocular trauma, and peripheral retinal degeneration. Population-based studies also show geographical variation in RRD epidemiology (1).

Macular involvement is clinically important because foveal detachment compromises central vision and may interfere with preoperative ocular biometry. Pakistani data indicate that RRD contributes substantially to vitreoretinal surgical workload, with many patients presenting with macular involvement and requiring pars plana vitrectomy (2). Achieving an acceptable postoperative refractive outcome is therefore an important component of visual rehabilitation.

Combined phacoemulsification and pars plana vitrectomy (phacovitrectomy) permits simultaneous treatment of cataract and retinal pathology. However, accurate IOL power calculation can be difficult in macula-off RRD because axial-length measurement of the affected eye may terminate at the detached retina and underestimate the true axial length. El-Khayat et al. reported better refractive accuracy using fellow-eye biometry than same-eye biometry in macula-off RRD (3). Liu et al. similarly found that A-scan ultrasonography underestimated axial length compared with postoperative measurements, whereas fellow-eye axial length showed closer agreement (4).

Postoperative refraction may also be influenced by IOL position, tamponade, and the calculation formula. Gas tamponade can alter IOL position and refractive outcome after phacovitrectomy (5), while contemporary formulas have improved prediction accuracy, with newer-generation formulas performing favorably in some phacovitrectomy cohorts (6). Combined phacovitrectomy is increasingly used for phakic RRD repair (7), although anterior-segment changes after surgery may still contribute to residual refractive error (8).

In Pakistan, access to advanced optical biometry may vary and patients may present with extensive macula-off detachment or media opacity that limits reliable optical measurement. The fellow eye may therefore provide a practical biometric reference when interocular symmetry is acceptable. Local evidence on this approach is limited. This study aimed to determine the accuracy of IOL calculations based on fellow-eye ultrasonic biometry and to compare refractive prediction with calculations based on the affected eye in patients undergoing phacovitrectomy for macula-off RRD.

MATERIALS AND METHODS

A prospective diagnostic accuracy study was conducted in the Department of Ophthalmology, Layton Rehmatullah Benevolent Trust (LRBT) Eye Hospital, Township, Lahore, from 18 February 2026 to 17 June 2026. Seventy-one consecutive patients with cataract and macula-off RRD undergoing combined phacoemulsification and pars plana vitrectomy were enrolled using non-probability consecutive sampling. The sample size was calculated using EpiTools on the basis of the mean absolute prediction errors reported by El-Khayat et al. (0.73 ± 0.80 D for fellow-eye biometry and 1.57 ± 2.08 D for same-eye biometry), with 95% confidence, 80% power, and a 5% level of significance (3). Ethical approval was obtained from LRBT and written informed consent was obtained from all participants.

Patients aged 18-70 years were eligible if they required phacovitrectomy for cataract with macula-off RRD and had either a phakic fellow eye or a pseudophakic fellow eye with available preoperative biometry. Patients with previous scleral buckling, recurrent or failed retinal detachment surgery, corneal disease, significant keratometric asymmetry, anisometropia >2.0 D, previous keratorefractive surgery, or intraoperative complications expected to affect IOL position were excluded.

Preoperative assessment included uncorrected and best-corrected visual acuity, intraocular pressure, slit-lamp biomicroscopy, keratometry using a Nidek KM-500 auto-keratometer, and axial-length measurement using PAC-SCAN A-scan ultrasonography. IOL power was calculated with the SRK/T formula, primarily from fellow-eye biometric measurements. The refractive target was selected according to fellow-eye refraction and patient preference. Affected-eye biometric measurements were also recorded to permit comparison of predictive accuracy.

All patients underwent standardized phacovitrectomy under local or general anesthesia by experienced vitreoretinal surgeons. Phacoemulsification with in-the-bag implantation of a foldable monofocal IOL was followed by pars plana vitrectomy and retinal detachment repair. The tamponade agent, including silicone oil or gas, was recorded. Cases with complications affecting final IOL position were excluded from refractive outcome analysis.

Patients were followed for at least 12 weeks. Those treated with silicone oil were assessed after at least six weeks following oil removal when applicable. Final subjective refraction was performed by an optometrist masked to the preoperative IOL calculation data. Prediction error was defined as postoperative minus predicted spherical equivalent; the absolute prediction error was the absolute value of this difference, and MAE was the average absolute prediction error.

Data were analyzed using IBM SPSS Statistics version 26.0. Continuous variables were summarized as mean $\pm$ standard deviation and categorical variables as frequency and percentage. Normality was assessed with the Shapiro-Wilk test. Paired continuous measurements were compared using the paired-samples t-test when normally distributed and the Wilcoxon signed-rank test otherwise. Paired categorical refractive-accuracy thresholds were compared using McNemar's test. A p-value <0.05 was considered statistically significant.

RESULTS

The mean age of the 71 patients was 52.8 ± 10.7 years (range, 24-70 years). Forty-four (62.0%) were male and 27 (38.0%) were female. The right eye was affected in 38 (53.5%) patients, and 68 (95.8%) fellow eyes were phakic. Silicone oil was used in 45 (63.4%) eyes and gas in 26 (36.6%). All included eyes had in-the-bag IOL implantation, successful retinal attachment, and eligible refractive follow-up (Table 1).

The affected eyes had a shorter mean axial length than the fellow eyes (23.31 ± 0.91 vs 23.66 ± 0.88 mm; mean difference -0.35 mm; $t = -6.86$; $p < 0.001$). K1, K2, and mean keratometry did not differ significantly between eyes (all $p > 0.05$) (Table 2).

Fellow-eye biometry produced a lower calculated IOL power than same-eye biometry (21.36 ± 2.47 vs 22.15 ± 2.58 D; $p < 0.001$) and a lower MAE (0.67 ± 0.53 vs 1.09 ± 0.77 D; $p < 0.001$). Absolute prediction error was within ± 0.50 D in 54.9% of fellow-eye calculations compared with 31.0% of same-eye calculations ($p = 0.004$), and within ± 1.00 D in 83.1% versus 60.6% ($p = 0.003$). Differences remained significant at ± 1.50 D but not at ± 2.00 D (Table 3).

Table 1. Demographic, baseline, surgical, and postoperative characteristics (n=71)

Characteristic	n (%) / Mean $\pm$ SD
Age, years	52.8 ± 10.7
Age range, years	24-70
Age group 18-30 years	4 (5.6)

Age group 31-40 years	10 (14.1)
Age group 41-50 years	18 (25.4)
Age group 51-60 years	21 (29.6)
Age group 61-70 years	18 (25.4)
Male	44 (62.0)
Female	27 (38.0)
Right eye affected	38 (53.5)
Left eye affected	33 (46.5)
Fellow eye phakic	68 (95.8)
Fellow eye pseudophakic with prior biometry	3 (4.2)
Local anesthesia	57 (80.3)
General anesthesia	14 (19.7)
Silicone-oil tamponade	45 (63.4)
Gas tamponade	26 (36.6)
In-the-bag IOL implantation	71 (100.0)
Successful retinal attachment at final assessment	71 (100.0)
Eligible refractive follow-up completed	71 (100.0)

Data are presented as mean±standard deviation or frequency (percentage), as appropriate. IOL: intraocular lens.

Table 2. Comparison of preoperative biometric parameters between affected and fellow eyes

Parameter	Affected eye Mean±SD	Fellow eye Mean±SD	Mean difference	t value	p-value
Axial length, mm	23.31±0.91	23.66±0.88	-0.35	-6.86	<0.001
K1, D	43.18±1.39	43.14±1.35	0.04	1.08	0.284
K2, D	44.21±1.47	44.17±1.43	0.04	1.00	0.322
Mean keratometry, D	43.70±1.39	43.66±1.35	0.04	1.18	0.241

Paired-samples t-test was used. D: diopter.

Table 3. Comparison of IOL calculation and postoperative refractive accuracy using fellow-eye and same-eye biometry

Outcome	Fellow-eye biometry	Same-eye biometry	Difference / test statistic	p-value
Calculated IOL power, D	21.36±2.47	22.15±2.58	Mean diff -0.79; t=-6.21	<0.001*
Predicted postoperative SE, D	-0.16±0.24	-0.87±0.69	Mean diff 0.71; t=8.02	<0.001*
Mean prediction error, D	-0.08±0.84	0.63±1.10	Mean diff -0.71; t=-5.84	<0.001*
Mean absolute prediction error, D	0.67±0.53	1.09±0.77	Mean diff -0.42; t=-5.36	<0.001
Absolute prediction error ≤0.50 D	39 (54.9%)	22 (31.0%)	$\chi^2=8.33$	0.004
Absolute prediction error ≤1.00 D	59 (83.1%)	43 (60.6%)	$\chi^2=8.82$	0.003
Absolute prediction error ≤1.50 D	66 (93.0%)	55 (77.5%)	$\chi^2=6.86$	0.009
Absolute prediction error ≤2.00 D	67 (94.4%)	60 (84.5%)	$\chi^2=3.77$	0.052
Absolute prediction error >2.00 D	4 (5.6%)	11 (15.5%)	$\chi^2=3.77$	0.052

Continuous data are mean±SD. *Paired-samples t-test was used for normally distributed paired continuous variables; McNemar's test was used for paired categorical thresholds. IOL: intraocular lens; SE: spherical equivalent; D: diopter.

DISCUSSION

The present study showed that fellow-eye biometry provided better refractive prediction than same-eye biometry in patients undergoing phacovitrectomy for macula-off RRD. The affected eye had a shorter axial length than the fellow eye (23.31±0.91 vs 23.66±0.88 mm; $p<0.001$), whereas K1, K2, and mean keratometry were comparable. This pattern suggests that axial-length distortion, rather than corneal-power asymmetry, was the main biometric source of error. Helaly et al. also demonstrated clinically relevant variability in preoperative axial-length measurements in macula-off RRD and showed that measurement technique influenced agreement with postoperative axial length (9).

The MAE in our study was 0.67±0.53 D with fellow-eye biometry compared with 1.09±0.77 D with same-eye measurements ($p<0.001$). These findings support the use of the fellow eye when operated-eye measurements are unreliable. Lwowski et al. similarly found that fellow-eye axial length could provide a useful alternative for IOL calculation in retinal-detachment eyes (10). Kaiser et al. reported median absolute errors of 1.00 D using complete

fellow-eye data and 1.02 D when fellow-eye axial length was combined with measurable operated-eye parameters ($p=0.712$), indicating that fellow-eye information can remain clinically useful, although reliable operated-eye optical biometry may be preferable when obtainable (11).

The shorter affected-eye axial length is biologically plausible because A-scan ultrasound may detect the detached retina instead of the normal retinal pigment epithelium-choroidal interface, leading to an artificially short measurement and excessive calculated IOL power. Liu et al. reported axial lengths of 25.39 ± 2.14 mm with A-scan ultrasound, 25.85 ± 2.16 mm using the fellow eye, and 26.08 ± 2.53 mm after retinal repair; corresponding IOL powers were 16.81 ± 7.19 D, 14.74 ± 6.95 D, and 13.54 ± 8.32 D (4). This is consistent with our finding that same-eye calculations produced a higher IOL power than fellow-eye calculations (22.15 ± 2.58 vs 21.36 ± 2.47 D; $p<0.001$).

Formula-related and surgical factors may also contribute to refractive error. Tanaka et al. reported a Barrett Universal II mean prediction error of -0.59 ± 0.34 D after phacovitrectomy with gas for RRD compared with -0.08 ± 0.37 D after phacoemulsification alone ($p<0.01$) (12). Chen et al. reported an overall MAE of 0.65 D with Barrett Universal II in eyes undergoing combined vitreoretinal and cataract surgery, with primary retinal-detachment eyes showing relatively poor refractive performance (13). These findings suggest that improved formulas do not eliminate the effect of underlying retinal pathology and measurement quality.

Tamponade may further influence postoperative refraction. Silicone oil was used in 63.4% of our patients and gas in 36.6%. Lwowski et al. demonstrated clinically meaningful differences in prediction accuracy among eight IOL formulas in silicone-oil-filled eyes (14). Hou et al. and Zhang et al. also reported that formula selection affected refractive prediction in eyes undergoing cataract surgery with silicone-oil removal (15,16). Thus, postoperative refractive outcome is likely determined by a combination of axial-length measurement, tamponade, IOL position, and formula characteristics.

Clinically, 54.9% of patients were within ±0.50 D with fellow-eye biometry compared with 31.0% using same-eye measurements, while 83.1% versus 60.6% were within ±1.00 D. Contemporary studies continue to show that refractive predictability after phacovitrectomy is influenced by both ocular and surgical variables (17). Roh et al. identified biometric and anatomical determinants of prediction error after phacovitrectomy (18), and Buhl et al. reported measurable refractive differences after combined phacovitrectomy (19). Wang et al. likewise showed that IOL estimation can remain challenging in silicone-oil-dependent eyes (20).

These findings support fellow-eye biometry as a practical option when macula-off RRD compromises affected-eye axial-length measurement. The approach should, however, be restricted to patients with reasonable interocular symmetry because substantial anisometropia, previous contralateral ocular surgery, or asymmetric axial anatomy may reduce reliability. The study was conducted at a single tertiary eye hospital and used the SRK/T formula with ultrasound biometry; therefore, the findings may not directly generalize to centers using optical biometry or newer-generation formulas. Larger multicenter studies comparing ultrasound and contemporary optical biometers would further define the role of fellow-eye substitution.

CONCLUSION

In patients with macula-off RRD undergoing phacovitrectomy, fellow-eye ultrasonic biometry provided significantly better refractive prediction than affected-eye biometry, with a lower mean absolute prediction error and a greater proportion of eyes achieving postoperative refraction within ±0.50 D and ±1.00 D of the predicted target. Fellow-eye measurements may therefore be used as a practical alternative when affected-eye axial-length measurements are unreliable, provided clinically important interocular asymmetry has been excluded.

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