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Refractive outcomes and biometric prediction accuracy following Optiflex Trio trifocal intraocular lens implantation

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Abstract

Background To assess the refractive performance and predictive reliability of four commonly used intraocular lens (IOL) power calculation formulas in eyes receiving the Optiflex Trio lens.

Methods This retrospective analysis included 554 eyes of 348 individuals who underwent phacoemulsification followed by Optiflex Trio IOL implantation for either visually significant cataracts or refractive lens exchange. Preoperative and postoperative measurements including refraction, keratometry, and visual acuity, were reviewed. The prediction errors generated by the SRK/T, Hoffer Q, Barrett Universal II, and Haigis-L formulae were compared.

Results Participants had a mean age of 61.46 ± 9.87 years. Cataract removal occurred in 481 eyes (86.8%), whereas 73 eyes (13.2%) underwent refractive lens exchange. The spherical equivalent (SE) changed from a preoperative value of + 0.21 ± 2.71 D to − 0.31 ± 0.56 D postoperatively ($p < 0.001$). After surgery, 44.2% of eyes were within ± 0.25 D of the target refraction, 70.2% within ± 0.50 D, and 92.1% within ± 1.00 D. All formulas showed a tendency to produce hyperopic predictions relative to actual postoperative outcomes ($p < 0.001$). Although the mean prediction errors did not differ significantly among formulas ($p = 0.712$), threshold-based analysis demonstrated meaningful differences at ± 0.25 D and ± 0.50 D ($p = 0.024$ and $p < 0.001$, respectively). Across all benchmarks, the Barrett Universal II formula yielded the highest proportion of eyes that met the specified accuracy level.

Conclusions In this large Optiflex Trio IOL cohort, more than 90% of the eyes achieved postoperative refractions within ± 1.00 D. Although the overall accuracy was comparable across formulas, Barrett Universal II provided superior precision at narrower tolerance limits, supporting its preferential use for IOL power calculation.

Keywords Biometry, Cataract, Refractive lens exchange, Intraocular lens formulas, Intraocular lens implantation

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Introduction

The primary objective of cataract surgery is to achieve optimal visual outcome. Advances in modern technology have led to significant improvements in the design of multifocal intraocular lenses (IOLs) [1]. Achieving optimal safety and efficacy relies on patient selection, accurate preoperative biometry, precise IOL power calculation, and surgical techniques [2]. Furthermore, increasing patient expectations have shifted cataract surgery toward refractive procedures with the primary goal of achieving the targeted postoperative refraction [3]. Over the last four decades, cataract surgeons have relied on a select group of established formulas, including Haigis, Hoffer Q, Holladay 1, Holladay 2, and SRK/T, to calculate IOL power before surgery, which are used in millions of cases worldwide. Simultaneously, new formulas for IOL calculations have been developed to further improve refractive outcomes [4].

The Optiflex Trio trifocal IOL (Biotech Healthcare Holding GmbH, Obergrundstrasse 17, 6002 Luzern, Switzerland), a single-piece hydrophobic acrylic aspheric lens incorporating a natural chromophore featuring a 360° square-edge design, has provided surgeons with advanced options for presbyopia correction [5]. However, the optimal IOL power calculation formula for this lens remains the subject of ongoing research. Although several trifocal IOL platforms have been widely investigated, evidence on the Optiflex Trio remains scarce. Therefore, evaluating the postoperative refractive outcomes in a large cohort provides clinically relevant insights that have not yet been addressed in the literature.

This study aimed to determine the relative accuracy of four commonly used IOL power calculation formulas, SRK/T, Hoffer Q, Barrett Universal II, and Haigis-L, in eyes implanted with the Optiflex Trio trifocal IOL. By systematically comparing the predicted and actual postoperative refractions across a large patient cohort, this study provides robust evidence for the reliability of the formula. These findings can be used to guide formula selection, optimize surgical outcomes, and enhance visual quality and patient satisfaction in contemporary cataract and refractive lens exchange practice.

Materials and methods

Study design

This single-center retrospective study aimed to evaluate postoperative outcomes and to compare the prediction accuracy of four commonly used biometry formulas, SRK/T, Hoffer Q, Barrett Universal II, and Haigis-L, in eyes receiving the Optiflex Trio trifocal intraocular lens following cataract surgery or refractive lens exchange. The investigation was conducted in accordance with the principles of the Declaration of Helsinki and approved by the local institutional ethics committee (approval date: 18.09.2025 and no:381). As this study involved a retrospective review of existing records, the requirement for written informed consent was waived.

Inclusion and exclusion criteria

The study included 554 eyes of 348 patients who underwent phacoemulsification with implantation of the Optiflex Trio trifocal IOL for either visually significant cataract or refractive lens exchange. The inclusion criteria were as follows: for cataract patients, age-related cataracts with a preoperative lens nuclear hardness grade of 2–3; [6] for the refractive lens exchange group, patients seeking correction of refractive errors, including myopia, hyperopia, and/or presbyopia; and for all eyes, axial length between 20 and 26 mm and regular corneal astigmatism of less than 0.75–1.00 diopters (D). The exclusion criteria were preexisting ocular conditions that could affect refractive outcomes (e.g., glaucoma, retinal disease, corneal pathology, uveitis, or dry eye syndrome), irregular corneal astigmatism, a history of ocular surgery, intraoperative or postoperative complications (including IOL decentration or posterior capsule opacification), unexpected postoperative astigmatism, and failure to adhere to scheduled follow-up visits.

Preoperative evaluation

All patients underwent a standard preoperative assessment, which included a full ophthalmic evaluation. This consisted of manifest refraction, measurement of uncorrected and corrected distance visual acuity at 4 m using a Snellen chart, slit-lamp examination, fundus evaluation, optical biometry using the Lenstar LS-900 (Haag-Streit, Bern, Switzerland), and corneal topography obtained using the Sirius system (CSO, Florence, Italy). Preoperative records included demographic information, refractive parameters such as spherical equivalent (SE) and astigmatism, flat and steep keratometry readings (K1 and K2), and uncorrected and corrected distance visual acuities. IOL power selection was primarily based on the Barrett Universal II formula, with a target of emmetropia, and the chosen power was documented. Predicted postoperative refractive outcomes for the implanted lenses were also calculated using the SRK/T, Hoffer Q, Barrett Universal II, and Haigis-L formulas derived from optical biometry measurements.

Surgical procedure and postoperative evaluation

All procedures were performed by a single experienced surgeon (ŞCİ) using a standard phacoemulsification approach through a 2.4 mm clear corneal incision. Following the creation of a continuous curvilinear capsulorhexis, the crystalline or clear lens was removed and the Optiflex Trio intraocular lens was placed within the capsular bag. Corneal wounds were hydrated to achieve

a secure seal. All surgeries were performed without intraoperative complications. After surgery, patients followed a uniform postoperative regimen consisting of a combination of antibiotic and corticosteroid eye drops, administered four times daily for one month. Follow-up examinations were scheduled at 1 day, 1 week, 1 month, and 6 months after surgery. During the 6-month visit, the uncorrected and corrected distance visual acuity, uncorrected intermediate vision at 66 cm, uncorrected near vision at 40 cm, refractive status (SE and astigmatism), and keratometry readings (K1 and K2) were documented. For each biometry formula, prediction error was calculated by subtracting the actual postoperative SE from the predicted postoperative refraction.

Optiflex Trio trifocal intraocular lens

The Optiflex Trio intraocular lens is a trifocal device featuring a combined diffractive-refractive design, 360° square-edge profile, and aspheric optics, and was specifically developed for the correction of presbyopia. It is manufactured using hydrophobic acrylic materials that incorporate naturally occurring chromophores. The lens has a 6.00 mm optic diameter and a total length of 13.00 mm, with a refractive index of 1.48. The Optiflex Trio IOL provides additional powers of + 1.85 D for intermediate vision and + 3.50 D for near vision, targeting functional reading distances of approximately 72 cm and 38 cm, respectively. Its material composition, along with embedded natural yellow chromophores, is designed to reduce the risk of age-related macular degeneration, minimize disruption of circadian rhythms, and preserve natural color perception [5, 7].

Table 1 The demographic and clinical characteristics of the study patients and eyes

Patients, n	348	
Eyes, n	554	
Age, years	61.46 ± 9.87	
Sex, male / female	207 / 141	
Indication, cataracts / refractive	481 / 73	
IOL power, D	22.41 ± 2.61	
Uncorrected distance visual acuity, logMAR		
Preoperative	0.61 ± 0.29	**$p < 0.001$**[a]
Postoperative	0.04 ± 0.02	
Corrected distance visual acuity, logMAR		
Preoperative	0.37 ± 0.18	**$p < 0.001$**[a]
Postoperative	0.01 ± 0.02	
SE, diopters		
Preoperative	+ 0.21 ± 2.71	**$p < 0.001$**[a]
Postoperative	-0.31 ± 0.56	
Astigmatism, D		
Preoperative	-0.03 ± 1.03	**$p < 0.001$**[a]
Postoperative	-0.58 ± 0.67	
K_1, D		
Preoperative	43.37 ± 1.58	**$p = 0.018$**[b]
Postoperative	43.33 ± 1.60	
K_2, D		
Preoperative	44.00 ± 1.61	**$p = 0.40$**[b]
Postoperative	43.98 ± 1.64	
Eyes with postoperative SE within ± 0.25 D, n (%)	245 (44.2%)	
Eyes with postoperative SE within ± 0.50 D, n (%)	389 (70.2%)	
Eyes with postoperative SE within ± 1.00 D, n (%)	510 (92.1%)	

D, diopters; IOL, intraocular lens; K_1, flat keratometry; K_2, steep keratometry; SE, spherical equivalent

[a] Wilcoxon signed rank test

[b] Paired samples t-test

Statistical analysis

All statistical analyses were conducted using the SPSS software (version 28, IBM Corp., Armonk, NY, USA). The Shapiro-Wilk test was used to assess the normality of continuous variables. Continuous data were reported as means with standard deviations, whereas categorical variables were presented as frequencies and percentages. For comparisons between preoperative and postoperative measurements, paired samples t-tests were used when data followed a normal distribution; otherwise, the Wilcoxon signed-rank test was applied. The biometric prediction accuracy was evaluated by calculating the prediction error, which is defined as the difference between the predicted refraction and the postoperative SE. The distribution of prediction errors among the formulas was analyzed using the Friedman test. The proportions of eyes achieving outcomes within ± 0.25 D, ± 0.50 D and ± 1.00 D of the intended target were compared using Cochran's Q test. Statistical significance was set at $p < 0.05$.

Results

This study included 554 eyes of 348 patients. The mean age of the cohort was 61.46 ± 9.87 years (range, 16–86). Two hundred and seven patients (59.5%) were male and 141 (40.5%) were female. Among the eyes included in the study, 201 (36.2%) were myopic and 353 (63.8%) were hyperopic (Table 1).

The primary indication for surgery was the presence of visually significant cataracts in 481 eyes (86.8%), and 73 eyes (13.2%) underwent refractive lens exchange. The mean implanted IOL power was 22.41 ± 2.61 D (Table 1).

Uncorrected distance visual acuity showed a significant improvement, changing from a preoperative value of 0.61 ± 0.29 logMAR to 0.04 ± 0.02 logMAR following surgery (Wilcoxon signed-rank test, $p < 0.001$). Corrected distance visual acuity also improved substantially, rising from 0.37 ± 0.18 logMAR preoperatively to 0.01 ± 0.02 logMAR postoperatively (Wilcoxon signed-rank test, $p < 0.001$) (Table 1).

The mean preoperative SE was slightly hyperopic at +0.21 ± 2.71 D, which shifted significantly toward myopia postoperatively, reaching −0.31 ± 0.56 D (Wilcoxon signed-rank test, $p < 0.001$). The mean preoperative astigmatism of -0.03 ± 1.03 D increased significantly in magnitude postoperatively to -0.58 ± 0.67 D (Wilcoxon signed-rank test, $p < 0.001$) (Table 1).

The keratometric values remained clinically stable after surgery. The mean K_1 decreased slightly from 43.37 ± 1.58 D to 43.33 ± 1.60 D (paired-samples t-test, $p = 0.018$); however, this change was clinically negligible. No significant difference in K2 from the preoperative values was detected (44.00 ± 1.61 D preoperatively vs. 43.98 ± 1.64 D postoperatively; paired-samples t-test, $p = 0.40$) (Table 1).

Following surgery, 245 eyes (44.2%) achieved a postoperative SE within ± 0.25 D of the intended refraction, 389 eyes (70.2%) were within ± 0.50 D, and 510 eyes (92.1%) were within ± 1.00 D (Table 1; Fig. 1).

When we compared the predicted and achieved postoperative refractive errors, all four biometric formulas significantly overestimated hyperopia relative to the actual postoperative refraction (Wilcoxon signed-rank test, $p < 0.001$ for all) (Table 2).

The mean prediction error was similar across the four biometry formulas, measuring 0.33 ± 0.58 D for SRK/T, 0.34 ± 0.59 D for Hoffer Q, 0.31 ± 0.56 D for Barrett Universal II, and 0.33 ± 0.59 D for Haigis-L (Friedman test, $p = 0.71$). Analysis of the proportion of eyes within prediction error thresholds revealed statistically significant differences among the formulas for the ± 0.25 D and ± 0.50 D categories, whereas no significant difference was observed for the ± 1.00 D threshold. The Barrett Universal II formula achieved the highest proportion of eyes at all the thresholds. Specifically, the percentages of eyes within ± 0.25 D, ± 0.50 D, and ± 1.00 D were 31.8%, 58.1%, and 89.5% for SRK/T; 29.8%, 59.4%, and 90.1% for Hoffer Q; 34.7%, 64.4%, and 90.6% for Barrett Universal II; and 30.3%, 60.5%, and 89.5% for Haigis-L, respectively (Cochran's Q test; $p = 0.024$, $p < 0.001$, and $p = 0.44$, respectively) (Table 3; Fig. 2).

Discussion

This study reports the refractive and visual performance of the Optiflex Trio trifocal intraocular lens in the largest patient group examined to date, comprising 554 eyes. The findings demonstrate that the lens provides strong uncorrected vision at distance, intermediate, and near ranges, with more than 90% of eyes reaching a postoperative refraction within ± 1.00 D. Although a slight postoperative increase in astigmatism was noted, this change

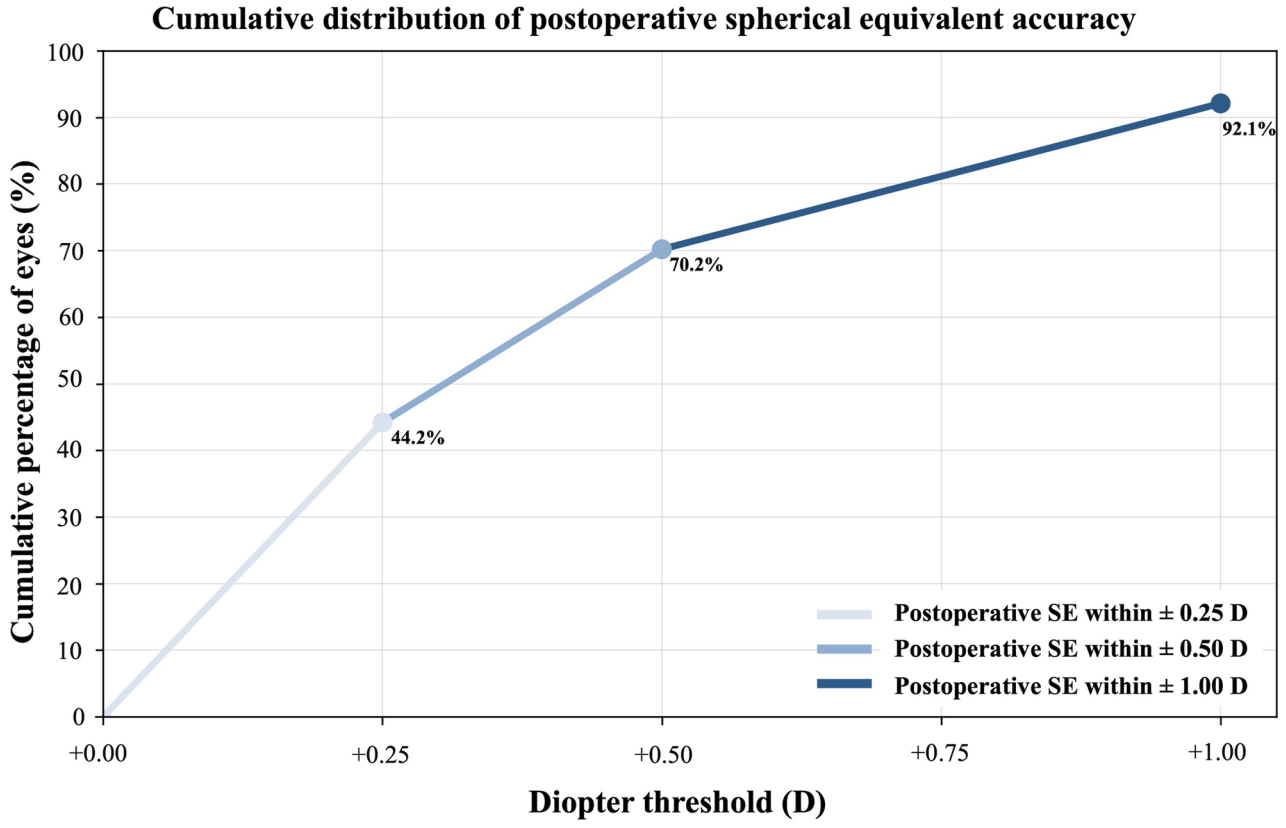

Fig. 1 Cumulative distribution of postoperative spherical equivalent accuracy. The curve demonstrates the proportion of eyes achieving refractive outcomes within increasing diopter thresholds (± 0.25 D, ± 0.50 D, and ± 1.00 D)

Table 2 Comparison of predicted and actual postoperative refraction for each biometry formula

	Postoperative predicted refractive error mean ± SD median [min – max]	**Postoperative actual refractive error mean ± SD median [min – max]**	***p* value***
SRK/T	+0.02 ± 0.16 +0.02 [(-0.59) – (+0.67)]	-0.31 ± 0.56 -0.25 [(-3.50) – (+3.13)]	**< 0.001**
Hoffer Q	+0.03 ± 0.16 +0.01 [(-0.64) – (+0.76)]	-0.31 ± 0.56 -0.25 [(-3.50) – (+3.13)]	**< 0.001**
Barrett Universal II	+0.00 ± 0.11 +0.01 [(-0.80) – (+0.18)]	-0.31 ± 0.56 -0.25 [(-3.50) – (+3.13)]	**< 0.001**
Haigis-L	+0.02 ± 0.16 +0.01 [(-0.64) – (+0.68)]	-0.31 ± 0.56 -0.25 [(-3.50) – (+3.13)]	**< 0.001**

* Wilcoxon signed rank test

Table 3 Comparison of the performance of biometry formulas in predicting postoperative refractive error

	SRK/T	**Hoffer Q**	**Barrett Universal II**	**Haigis-L**	***p* value**
Prediction error*, D (mean ± SD)	+0.33 ± 0.58	+0.34 ± 0.59	+0.31 ± 0.56	+0.33 ± 0.59	0.71[a]
Eyes with prediction error within ± 0.25 D, n (%)	176 (31.8%)	165 (29.8%)	192 (34.7%)	168 (30.3%)	**0.024[b]**
Eyes with prediction error within ± 0.50 D, n (%)	322 (58.1%)	329 (59.4%)	357 (64.4%)	335 (60.5%)	**< 0.001[b]**
Eyes with prediction error within ± 1.00 D, n (%)	496 (89.5%)	499 (90.1%)	502 (90.6%)	496 (89.5%)	0.44[b]

D, diopters; SD, standard deviation

* Prediction error was calculated by subtracting the actual postoperative spherical equivalent value from the predicted postoperative refraction for each biometry formula

[a] Friedman test

[b] Cochran's Q test

did not negatively affect overall visual results. Keratometry readings remained stable, indicating both consistent surgical execution and good positional stability of the Optiflex Trio lens. Although the four biometry formulas showed comparable mean prediction errors, all exhibited a similar hyperopic tendency of around +0.31 D. Among them, the Barrett Universal II formula produced the greatest proportion of eyes within the ±0.25 D and ±0.50 D accuracy limits, indicating a modest advantage in refractive predictability.

In line with our findings, Brar et al. [8] prospectively evaluated 54 eyes implanted with the Optiflex Trio trifocal IOL and reported excellent visual outcomes across all distances along with high levels of spectacle independence at 12 months of follow-up. Notably, 93% of the eyes were within ± 0.50 D of the target refraction, underscoring the refractive predictability of this IOL. Although their study involved a smaller cohort, its prospective design and inclusion of patient-reported outcomes provided valuable clinical insights into the performance of the Optiflex Trio trifocal IOL. Collectively, these results support the Optiflex Trio as a reliable trifocal IOL that achieves highly accurate refractive outcomes while ensuring high patient satisfaction and functional vision in real-world clinical practice.

Accurate determination of IOL power is essential in refractive cataract surgery, as postoperative visual quality and patient satisfaction depend heavily on its precision [9]. The results of this study align with previous research demonstrating the dependable performance of the SRK/T, Hoffer Q, and Barrett Universal II formulas in eyes with a normal axial length [10, 11]. In line with earlier studies [11], the Barrett Universal II formula showed a slight advantage, yielding a greater proportion of eyes within narrower prediction error ranges. This underscores its usefulness in patients receiving premium IOLs, where even minimal deviations from intended refraction can affect visual satisfaction.

Accurate formula selection is especially important for trifocal IOLs, because the premium cost of these implants and patients' desire for spectacle independence magnify the impact of small refractive deviations. The intraocular lens power estimation error, defined as the difference between the predicted and observed refraction, indicates whether postoperative outcomes tend toward hyperopia or myopia [10]. Notably, our study revealed a consistent hyperopic shift of approximately + 0.31 D across all formulas. Although this deviation did not compromise the excellent postoperative visual acuity achieved in our cohort, it highlights the importance of lens constant optimization for the Optiflex Trio IOL. Even minor variations in the effective lens position can significantly affect postoperative refraction, particularly in patients receiving trifocal lenses, which are highly sensitive to refractive errors [12]. Based on our results, the uniform direction and magnitude of the shift across all formulas may suggest that this finding is less likely attributable to formula-specific inaccuracies and more

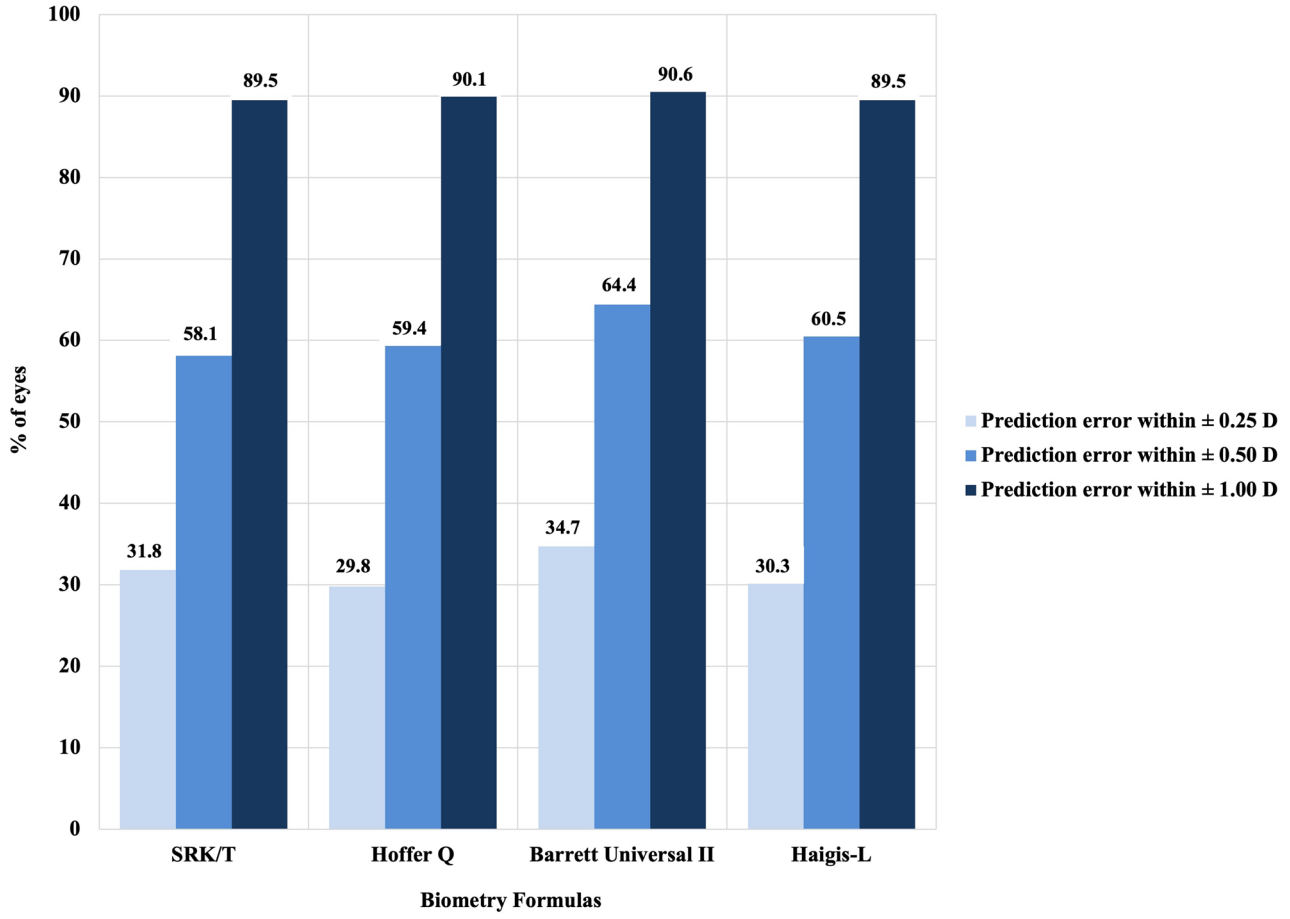

Fig. 2 Distribution of postoperative prediction errors according to different biometry formulas. Light, moderate, and dark blue colors represent prediction errors within ± 0.25 D, ± 0.50 D, and ± 1.00 D, respectively. More than 90% of the eyes were within ± 1.00 D of prediction error for all the formulas, with the Barrett Universal II formula yielding the highest proportion of eyes across all the thresholds

plausibly related to lens-specific features affecting effective lens position. Variations in capsular bag behavior, IOL geometry, or haptic design may have systematically influenced the final refractive outcome, supporting a lens-related component. From a clinical perspective, surgeon-specific adjustment of lens constants may reduce systematic prediction error and enhance refractive precision. Alternatively, targeting a slight myopic outcome may represent a suitable strategy in patients receiving trifocal IOLs. Prospective studies incorporating optimized constants and individualized refractive targets are warranted to determine whether this hyperopic shift can be effectively minimized.

Large-scale data involving premium multifocal IOLs suggest that newer formulas, such as Kane and EVO 2.0, achieve greater refractive accuracy, as reflected by their lower standard deviations than legacy formulas [13]. Clinically, long-term follow-up of trifocal IOL recipients reveals minor hyperopic shifts over time, especially in younger patients, despite overall refractive stability [14].

Several investigations have compared the Barrett Universal II formula with other IOL power calculation methods and have consistently reported superior performance across different ocular profiles [11, 15]. Kane et al. [15] found that the Barrett Universal II formula had the highest proportion of eyes within ± 0.50 D compared with Haigis, Hoffer Q, Holladay 1, Holladay 2, SRK/T, and T2 in eyes implanted with Acrysof IQ SN60WF IOL. Similarly, Shajari et al. [16] reported that Barrett Universal II was the most accurate formula for the Acrysof IQ PanOptix TFNT00 IOL in eyes with moderate axial lengths based on the mean absolute prediction error. Our findings align with these results, demonstrating that Barrett Universal II offered the highest precision, particularly within the ± 0.25 D and ± 0.50 D ranges, despite all formulas yielding excellent accuracy within ± 1.00 D. It should also be noted that the optimal formula may differ in eyes with short or long axial lengths, underscoring the need for individualized formula selection [17, 18].

Although statistically significant differences were observed at the ± 0.25 D and ± 0.50 D thresholds, the

absolute differences between formulas were relatively small. In conventional monofocal cataract surgery, variations of this magnitude would be unlikely to have meaningful clinical implications. However, refractive precision has greater importance in eyes implanted with trifocal intraocular lenses, as multifocal optical designs are sensitive to even minor residual refractive errors, which may compromise contrast sensitivity and patient-perceived visual quality. Accordingly, achieving narrower prediction error margins may enhance spectacle independence and overall patient satisfaction in this population. Nevertheless, given the small magnitude of the observed differences, any apparent clinical superiority of one formula over another should be interpreted with caution.

The primary strengths of this study include its comparatively large sample size, the use of a single trifocal intraocular lens model, and the performance of all procedures by one experienced surgeon following a uniform surgical protocol. These elements helped to reduce the variability related to the surgical technique and lens design. Furthermore, this study represents the largest published cohort evaluating refractive outcomes using the Optiflex Trio Trifocal IOL. The inclusion of four commonly used biometry formulas also enhanced the clinical applicability of the results, ensuring that the conclusions are relevant to everyday practice.

This study has several limitations. Its retrospective design introduces potential selection bias and limits control over confounding variables. Moreover, the study population was restricted to eyes with normal axial lengths and low preoperative corneal astigmatism; therefore, the results may not be generalizable to extreme biometric profiles or to eyes with significant corneal irregularities. As only a single trifocal IOL platform was evaluated, the refractive outcomes may not be applicable to other multifocal or extended-depth-of-focus IOLs.

Although newer artificial intelligence-based formulas, such as Kane, Hill-RBF, and EVO 2.0, have demonstrated promising performance, they were not evaluated in our cohort, as the primary objective was to assess formulas that are widely accessible in routine clinical practice. Accordingly, the findings are intended to enhance applicability to everyday settings where advanced algorithms may not be readily available. Future prospective studies that directly compare traditional and artificial intelligence-driven formulas in Optiflex Trio recipients would provide valuable insights.

Astigmatism was evaluated solely in terms of cylindrical magnitude, without vector analysis. Therefore, axis-related changes could not be comprehensively assessed. Another methodological consideration relates to the inclusion of both eyes from a considerable proportion of participants, as the inherent biometric similarity between fellow eyes may have introduced intra-subject correlation, potentially inflating statistical power. Furthermore, the primary use of the Barrett Universal II formula for IOL power selection may have conferred a relative advantage to this formula. Accordingly, its slightly superior performance at narrower prediction error thresholds should be interpreted cautiously.

In conclusion, our findings not only validate the clinical performance of the Optiflex Trio in a real-world setting but also establish benchmark refractive outcomes that can serve as a reference for future studies on this lens. Although all formulas achieved satisfactory accuracy, the Barrett Universal II formula consistently demonstrated a modest advantage, particularly for tighter prediction error thresholds. These results reinforce the Optiflex Trio as a reliable trifocal IOL option and highlight the importance of considering formula selection and individualized constant optimization to further refine refractive outcomes in patients seeking spectacle independence.

Abbreviations

D	Diopter
IOL	Intraocular Lens
logMAR	Logarithm of the Minimum Angle of Resolution
SD	Standard Deviation
SE	Spherical Equivalent

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All authors have read and agreed to the published version of the manuscript.

Author contributions

All the authors contributed to the conception and design of the study. Material preparation, data collection, and analysis were performed by Şefik Can İpek, Mustafa Kayabaşı, Seher Köksaldı, and Cem Yıldırım, respectively. The first draft of the manuscript was written by Şefik Can İpek, Mustafa Kayabaşı, Seher Köksaldı, and Cem Yıldırım, and all authors commented on the previous versions of the manuscript. All authors have read and approved the final manuscript.

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Data availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Institutional review board statement

The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Ethics Committee of Agri Ibrahim Cecen University (approval date: 18.09.2025 and no:381).

Informed consent

Patient consent was waived because of the retrospective nature of this study.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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