Int J Ophthalmol, Vol. 18, No. 11, Nov. 18, 2025 www.ijo.cn
Tel: 8629-82245172 8629-82210956 Email: ijopress@163.com

· Clinical Research ·

Ocular biometric parameters associated with the performance of actual near-add power in multifocal intraocular lenses

Ying–Feng Hu[1], Yan Wang[1], Rong Zhang[1], Zheng Wang[1], Xiang–Yu Ye[1,2]

[1]Department of Cataract, Fuzhou Eye Hospital, Fuzhou 350007, Fujian Province, China
[2]Department of Cataract, Xiamen Eye Center and Eye Institute of Xiamen University, School of Medicine, Xiamen 361003, Fujian Province, China
Co-first Authors: Ying-Feng Hu and Yan Wang
Correspondence to: Xiang-Yu Ye. Fuzhou Eye Hospital, No.88, Liuyi South Road, Fuzhou 350007, Fujian Province, China. 609546088@qq.com
Received: 2024-12-31 Accepted: 2025-05-06

Abstract
● **AIM:** To evaluate the influence of ocular biometric parameters on the performance of actual near-add power in the spectacle plane of multifocal intraocular lenses (MIOLs).
● **METHODS:** This retrospective study defined prediction error (PE) as the difference between actual postoperative near-add power and manufacturer-predicted values. Linear regression assessed PE correlations with axial length (AL), mean keratometry (K), pupil size, anterior chamber depth (ACD), lens thickness (LT), ACD+0.5×LT, and back-calculated IOL power. Differences in PE across MIOLs types, AL, K, pupil size, ACD, LT, ACD+0.5×LT, and back-calculated IOL power groups were compared.
● **RESULTS:** Totally 250 eyes of 250 patients (116 males and 134 females, mean age 56.22±12.31y) who underwent phacoemulsification with MIOL implantation were reviewed. PE showed no significant correlation with most parameters but had a weak positive correlation with LT. The mean predicted error (MPE) in the AL≤22, 26–27, and 27–28 mm groups were 0.83 (0.51, 1.01) D, 0.78 (0.51, 1.07) D, and 0.72 (0.57, 0.94) D respectively (*P*<0.001). The MPE in the K between the 45–46 D groups was 0.78 (0.37, 1.07) D (*P*=0.0004). The MPE in the LT between the 4.5–5.0 mm groups and ≥5 mm was 0.72 (0.50, 1.01) D and 0.72 (0.51, 1.01) D respectively (*P*<0.001). The MPE in the back-calculated IOL power ≥25 D was 0.86 (0.60, 1.01) D (*P*<0.001).
● **CONCLUSION:** Although there is no significant linear relationship between near-add power and most ocular biometry parameters, and specific segments of AL, K, LT, and IOL power have a significant impact on the near-add power of MIOLs. These factors should be taken into account in preoperative evaluations.
● **KEYWORDS:** near-add power; multifocal intraocular lenses; spectacle plane
DOI:10.18240/ijo.2025.11.07

Citation: Hu YF, Wang Y, Zhang R, Wang Z, Ye XY. Ocular biometric parameters associated with the performance of actual near-add power in multifocal intraocular lenses. *Int J Ophthalmol* 2025;18(11):2065-2072

INTRODUCTION
In order to fulfill patients' demands for postoperative distance, intermediate, and near vision, multifocal intraocular lenses (MIOLs) have been widely used in the last decade[1]. The currently available MIOLs could offer a range of near-add power in the intraocular lens (IOL) plane from +1.5 D to +4 D[2-5]. Manufacturers provided the optimal reading distance of the multifocal IOL based on its near add power in the IOL plane[6-8]. Because of the differences in age, habits, and occupations, patients have different requirements and preferences for middle and near vision. The surgeons can choose a multifocal IOL with different near-add power based on the patient's actual near-working distance. However, it has been found that the actual near-add power in the spectacle plane that patients experience does not match the optimal reading distance provided by the manufacturer. Holladay and Hoffer's[9] study showed that patients with a deep anterior chamber who wanted to achieve an add power of 2.75 D in the spectacle plane required an IOL with a higher near-add power in the IOL plane compared to patients with a shallower anterior chamber. Similarly, Savini *et al*'s[7] study study found that patients with steep corneas and long axial lengths (AL) obtained lower postoperative near-add power in the spectacle plane. These studies suggest that the fixed IOL calculation model used by manufacturers may not accurately

Table 1 The predicted spectacle plane near-added power of the different MIOLs provided by the manufacturer

Manufacturer	MIOLs model	The plane add power of MIOLs	Optimal near focus distance (provided by manufacturer)	The predicted spectacle plane add power of MIOLs
Alcon	TFNTOO	+3.25 D	42 cm	+2.43 D
J&J Vision	ZMB00	+4.00 D	33 cm	+3.00 D
Carl Zeiss	809MP	+3.75 D	35 cm	+2.81 D
	839MP	+3.33 D	40 cm	+2.50 D

D: Diopters; MIOL: Multifocal intraocular lenses.

reflect the postoperative reality for each patient. It is crucial for accurately predicting postoperative near add power in the spectacle plane. There is a paucity of literature analyzing the factors influencing the near-add power of MIOLs based on actual clinical outcomes. This study presents the first clinical observations of the influence of effective lens position (ELP)-related ocular biometric parameters, pupil size, back-calculated IOL power, and different IOL types on the performance of actual near-add power. The findings provide valuable insights and serve as a reference for enhancing the clinical application of these parameters.

PARTICIPANTS AND METHODS

Ethical Approval This study was approved by the Ethics Committee at the Fuzhou Eye Hospital (No.FZYKYY-KY-2022-004) and conformed to the Declaration of Helsinki. All patients provided written consent papers.

Participants and Surgery This study retrospectively reviewed 250 eyes of 250 patients who underwent phacoemulsification with MIOL implantation at Fuzhou Eye Hospital from September 2022 to May 2024[10]. Theinclusion criteria for patient selection are as follows: 1) dark-adapted natural pupil diameter between 3.0 and 5.5 mm; 2) kappa angle <0.5 mm or kappa angle smaller than half of the central optical zone diameter of MIOLs, and corneal higher order aberrations (HOAs) within the central 4 mm region of the cornea <0.3 μm; 3) patients with a postoperative manifest best corrected visual acuity (BCVA) ≥20/25; 4) postoperative astigmatism ≤0.75 D. Patients with intraoperative or postoperative complications, traumatic cataracts, any optical clouding on slit lamp examination, severe dry eye, previous corneal refractive surgery, or intraocular surgery were excluded.

Standard cataract phacoemulsification surgery is performed by the same experienced surgeon. The models of IOLs implanted include AT LISA 809M (Carl Zeiss Meditec, Jena, Germany), AT LISA® tri 839M (Carl Zeiss Meditec, Jena, Germany), AcrySof® IQ PanOptix® TFNT00 (Alcon Vision LLC, Fort Worth, TX), and TECNIS® ZMB00 (Johnson & Johnson Vision, Santa Ana, California, USA).

Preoperative and Postoperative Examinations Every patient underwent complete ophthalmic examinations before and 1mo after surgery, including slit lamp examination, uncorrected distance visual acuity, corrected distance visual acuity, manifest and cycloplegic refraction, tonometry, and fundoscopy. Preoperative AL, mean keratometry (K), anterior chamber depth (ACD), and lens thickness (LT) were measured using an OA-2000 (Tomey Corporation, Japan). The patients' preoperative pupil size, corneal spherical aberration (SA), and corneal HOA were measured using the OPD-Scan III (Nidek Technologies, Gamagori, Japan).

Measured Spectacle Plane Near-add Power of MIOLs Monocular defocus curves were measured between +1.50 D and -4.00 D in 0.25 D steps 1mo after surgery. The curves are produced in this way. While viewing at a distant eye chart, the patient is adjusted for the best distance acuity in examining eye; this is the "zero" mark, which is, by definition, a peak for all lenses examined. Adjusting for optimal distance acuity eliminates variations in outcomes that could be caused by residual refractive error[11]. The actual postoperative near-add power in the spectacle planewasdefined as the dioptric distancebetween two peaks of optimum visual acuity.

Back-calculated IOL Power The implanted IOL power is determined based on the calculation of the patient's ocular biometric parameters. An accurate IOL power can reflect the comprehensive biological characteristics of the patient's eye. The back-calculated IOL power is defined as the postoperatively calculated IOL power required for emmetropia after surgery, based on the Barrett Rx Formula V2.0 (available at https://calc.apacrs.org/barrett_rx105/).

Calculation of the Prediction Error of Near-add Power In order to avoid statistical errors caused by different models of MIOLs, the prediction error (PE) is used to evaluate the postoperative near-add power actual performance. Based on the added power in the IOL plane and the optimal reading distance of the different MIOLs provided by the manufacturer, the predicted spectacle plane near-added power was converted using the same conversion coefficient (Table 1).

The predicted add power error is defined as the difference between the actual postoperative near-add power in the plane of the spectacle measured by monocular defocus curves and the predicted spectacle plane near-add power of the MIOLs provided by the manufacturer. A greater PE indicates better performance of postoperative near-add power.

Statistical Analysis Statistical analysis was performed using SPSS software (version 27.0, SPSS Inc., Chicago, USA). The

Table 2 Data sample characteristics *n*=250

Parameters	*n* (%)	Mean±SD	Range
Gender (female/male)	134/116 (53.6/46.4)		
Eye (OD/OS)	126/124 (50.4/49.6)		
Age (y)		56.22±12.31	26 to 73
AL (mm)		24.86±2.44	21.57 to 34.08
K (D)		44.13±1.60	39.54 to 48.49
ACD (mm)		3.23±0.44	1.47 to 4.13
Pupil size (mm)		3.36±0.60	2.38 to 5.6
Corneal SA (μm)		0.26±0.12	-0.29 to 0.5
Corneal HOA (μm)		0.16±0.09	0.04 to 0.3
IOL power (D)		17.04±6.62	-4 to +26
Postoperative SE (D)		-0.03±0.29	-1 to +0.75
Postoperative astigmatism (D)		0.40±0.28	0 to 0.75

D: Diopters; OD: Right eye; OS: Left eyes; IOL: Intraocular lens; AL: Axial length; K: Keratometry; ACD: Anterior chamber depth; SE: Spherical equivalent; SA: Spherical aberration; HOA: Higher order aberration.

normality of the data was checked using the Kolmogorov-Smirnov test. Linear regression analysis was performed to assess the relationship between the PE and the following variables: AL, K, pupil size, ACD, LT, ACD+0.5×LT, and back-calculated IOL power. The Kruskal-Wallis *H* test was used to examine the differences in PEs of near-add power among different types of MIOLs, along with the aforementioned variables. Significant differences were further tested using Bonferroni post hoc analysis. A *P*-value of less than 0.05 was considered statistically significant.

RESULTS

The study comprised 250 eyes of 250 patients. There were 116 males and 134 females, with a mean age of 56.22±12.31y. The preoperative AL, K, ACD, corneal SA, corneal HOA, postoperative spherical equivalent, postoperative astigmatism,and implanted IOL power are shown in Table 2.

The 87.2% of the patients had a postoperative near-add power greater than the manufacturer's predicted value. The PE is not significantly correlated with AL, K, ACD, ACD+0.5×LT, back-calculated IOL power, and pupil size (Figure 1A–1C, 1E–1G). However, it shows a weak positive correlation with LT (R^2=0.052 and P<0.001; Figure 1D).

There were no statistically significant differences in the PEs among the groups of different MIOLs types (P=0.579), pupil sizes (P=0.391), ACDs (P=0.08), and ACD+0.5×LT (P=0.08) values (Figure 2A, 2B, 2E, 2F).

The mean predicted error (MPE) in the AL ≤22, 26–27, and 27–28 mm groups were 0.83 (0.51, 1.01) D, 0.78 (0.51, 1.07) D, and 0.72 (0.57, 0.94) D respectively, which were statistically different from the other groups (P<0.001). The post hoc test detected significant differences between the 22–23 mm group and the 27–28 mm group (P=0.0308), the 23–24 mm group and the 26–27 mm group (P=0.0264), the 22–23 mm group and the 26–27 mm group (P=0.0058), the ≤22 mm group and the 22–23 mm group (P=0.0006), and the ≤22 mm group and the 23–24 mm group (P=0.0029). No differences were found in the rest of the comparisons (Figure 2C).

The MPE in the K between the 45–46 D groups was 0.78 (0.37, 1.07) D, which was statistically different from the other groups (P=0.0004). The post hoc test detected significant differences between the 42–43 D group and the 45–46 D group (P=0.0288), the 43–44 D group and the 45–46 D group (P=0.0021), and the 44–45 D group and the 45–46 D group (P=0.0009). No differences were found in the rest of the comparisons (Figure 2D).

The MPE in the LT between the 4.5–5.0 mm groups and ≥5 mm was 0.72 (0.50, 1.01) D and 0.72 (0.51, 1.01) D respectively, which were statistically different from the other groups (P<0.001). The post hoc test detected significant differences between the ≤4 mm group and the 4.5–5 mm group (P=0.0202), the ≤4 mm group and the ≥5 mm group (P=0.0265), the 4–4.5 mm group and the 4.5–5 mm group (P=0.0003), and the 4–4.5 mm group and the ≥5 mm group (P=0.0011). No differences were found in the rest of the comparisons (Figure 2G).

The MPE in the back-calculated IOL power ≥25D was 0.86 (0.60, 1.01) D, which was statistically different from the other groups (P<0.001). The post hoc test detected significant differences between the 15–20 D group and the ≥25 D group (P=0.0479), and the 20–25 D group and the ≥25 D group (P<0.001). No differences were found in the rest of the comparisons (Figure 2H).

DISCUSSION

The patient's need for near vision arises from the demands of their life and work, while the surgeon chooses different types of near-added multifocal IOLs according to the patient's

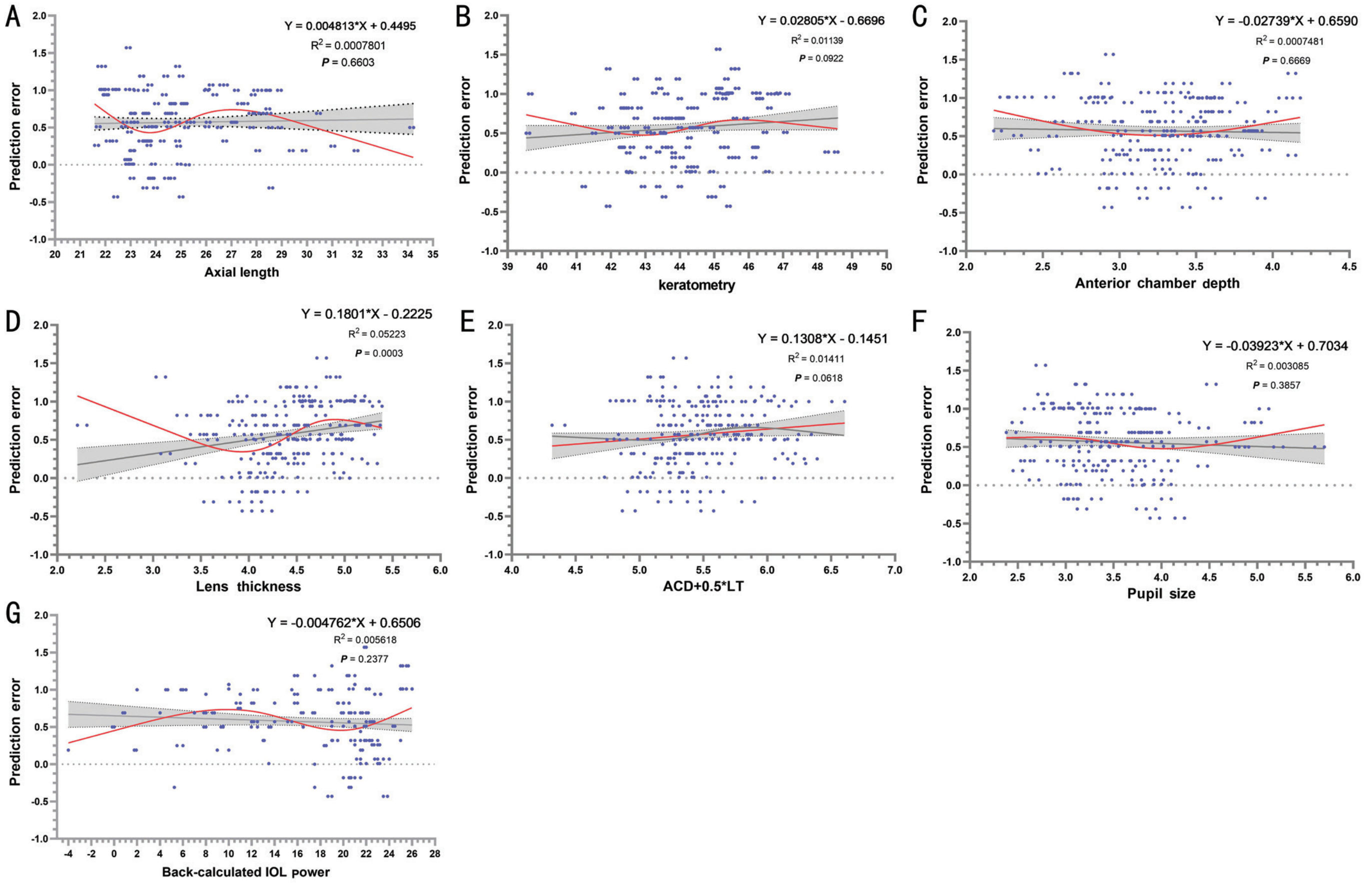

Figure 1 Scatter plot of prediction errors Linear regression analysis of the relationships between the PE and AL, K, pupil size, ACD, LT, ACD+0.5×LT, and back-calculated IOL power. The gray line represents the linear fit line. The red line represents a locally weighted scatterplot smoothing curve. IOL: Intraocular lens; ACD: Anterior chamber depth; LT: Lens thickness.

actual needs. However, clinical results revealed that patients implanted with the same near-added MIOLs had different optimal reading distances after surgery. Previous research indicates that the ELP significantly influences toric IOL performance[12-13] and impacts postoperative near-add power in the spectacle plane[7,14]. Savini *et al*[7] noted that hyperopic eyes tend to have closer near focal distances compared to myopic eyes.

Our study show no linear relationship between AL and PE. However, segmented analysis reveals that patients with an AL of less than 22 mm, or those with an AL in the range of 26–28 mm, have better actual near-add power in the plane of the spectacle. The findings in this study are consistent with previous research regarding near-add power in patients with short eyes. This result is understandable, as numerous studies have demonstrated that patients with shorter ALs may have a smaller ELP after surgery, leading to improved performance of the near-add power in the spectacle plane[15-17]. However, our results also showed that patients with AL between 26–28 mm had better actual near-add power, which is inconsistent with Savini *et al*'s[7] findings. The discrepancies between our study and Savini *et al*'s[7] study can be attributed to the differences in study design and methodology. Savini *et al*'s[7] results are theoretical values based on IOL calculation formulas such as SRK/T, Hoffer Q, and Holladay 1, while our study is based on real-world data. There are several studies have shown that the implantation of trifocal IOLs in myopic patients can achieve satisfactory outcomes[18-20]. We consider the following possible reasons: First, the ELP does not increase indefinitely as the AL increases. Additionally, the ELP is a parameter that is affected by various factors, which contribute to the limited accuracy of most IOL calculation formulas. In Savini *et al*'s[7] study, the focal distance also does not decrease with increasing AL in myopic eyes with steep corneas (K=45 D) in which calculations were performed with the Holladay 1 formula (due to the cusp effect of the SRK/T). This observed behavior is strictly dependent on the Holladay 1 formula and would not be observed with the Hoffer Q. Therefore, the actual near-add power is unlikely to have a simple linear relationship with the AL. Second, previous studies have shown that myopic patients may reduce their awareness of the blurring effect, which has been termed "neural and perceptual tolerance"[21-22], therefore the eyes of these patients may have a deeper depth of focus, which affects the results of performance at near-add power in MIOLs. Third, Patients with long eyes may also have steep corneas, small pupils, high SA, and higher-order aberrations, as

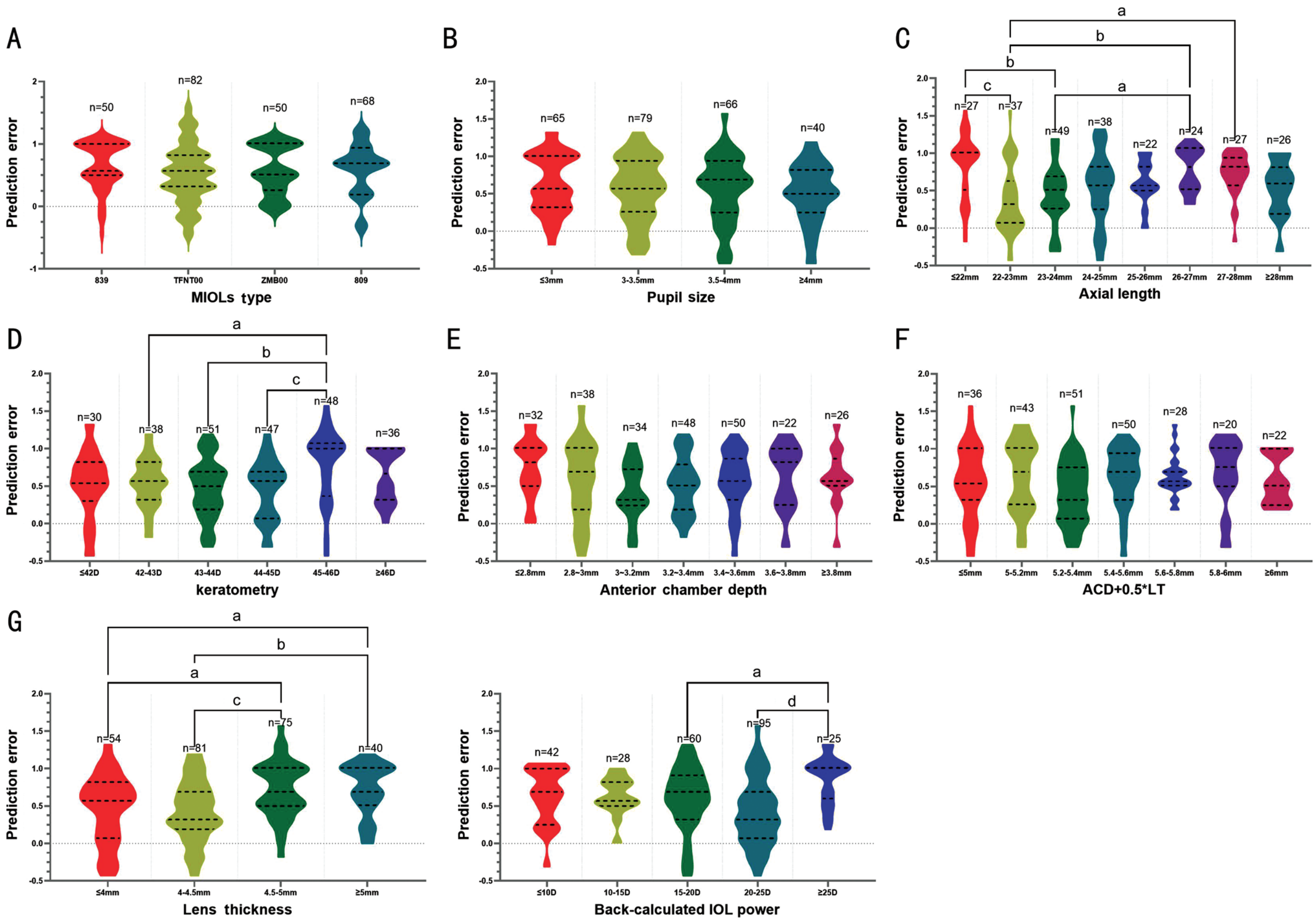

Figure 2 Violin plot of PEs Violin plot displaying the distribution of the PEs of different types of MIOLs, axial length, keratometry, pupil size, ACD, LT, ACD+0.5×LT, and back-calculated IOL power. MIOLs: Multifocal intraocular lenses; IOL: Intraocular lens; ACD: Anterior chamber depth; LT: Lens thickness; PE: Prediction error. ^{a}P<0.05; ^{b}P<0.01; ^{c}P<0.001; ^{d}P<0.0001.

well as other factors that could improve depth of focus, leading to a positive result.

K is commonly used as an important factor in predicting ELP and is widely incorporated into artificial lens calculation formulas. In Savini *et al*'s[7] study, all IOL formulas utilized K for ELP prediction, revealing that flatter corneas are associated with a narrower range of near focal distances compared to steeper corneas. Our study, however, did not find a linear correlation between corneal power and predictive error. Instead, segmental analysis revealed that the group with a K measurement between 45–46 D exhibited superior actual near-add power in the spectacle plane.The discrepancy between our findings and previous studies may be attributed to several factors. First, several studies have concluded that using K as a factor in predicting ELP for IOL power calculations usually leads to inaccurate IOL calculations in eyes with high and low mean K readings[23-25]. Therefore, using K to predict the near-add power based on the IOL calculation formula may be incorrect. Second, in our previous study, we found that when AL≤25.06 mm, K had a negative linear correlation with AL, and when AL>25.06 mm, K had a weak positive correlation with AL[26]. This implies that eyes with higher mean K readings tend to be shorter, which could explain the observed better near-add power. Third, in photography, according to the depth of field (DOF) calculation formula based on the optical system's object-image relationship the longer the focal length of the lens, the shorter the DOF. It means that when the lens has a greater refractive power, its DOF is also greater. Therefore, in previous understandings, it was believed that a steeper cornea would have a better DOF.

ACD and LT are considered important predictors of ELP and are used in a large number of IOL calculation formulas. Previous studies have also confirmed that patients with a smaller ACD have a smaller actual IOL position (ALP) postoperatively[27-29], theoretically suggesting better near-add power. However, the results of this paper show that no linear correlation was found between preoperative ACD and PE. Segmental analysis indicated that patients with smaller ACD seemed to have better near-add power, but there was no statistical difference between the groups, necessitating a larger sample size to confirm the findings. Numerous studies have confirmed that LT is highly correlated with preoperative

ACD[17,30]. In Olsen *et al*'s[31-32] study, the C constant was used to predict postoperative IOL position within the capsular bag based on preoperative LT and ACD. Additionally, some research uses the formula ACD+0.5×LT for predicting ELP and found that ELP is positively correlated with ACD+0.5×LT[27,33]. In this study, we analyze the impact of LT and ACD+0.5×LT on PE. No linear correlation between LT and PE was found in our data, but segmental analyses showed that patients with a large LT had better postoperative actual near-add power. Furthermore, analyses of ACD+0.5×LT and PE did not find a significant correlation. Patients with a large LT distribution in our sample tend to have a shorter AL and a shallower anterior chamber. This may be the reason why patients with a larger LT achieve better actual near-add power. In addition, many factors such as the size of the capsule bag, the laxity of the suspensory ligaments, and the liquefaction of the vitreous humor, may also affect ELP, therefore, the prediction of ELP remains complex and challenging.

This study also analyses the effect of the base refractive power of implanted MIOLs on their near-added power actual performance. The implanted IOL power is determined based on the calculation of the patient's ocular biometric parameters. An accurate IOL power can reflect the comprehensive biological characteristics of the patient's eye. When a high IOL power is needed, it is often associated with patients who have a short AL and a small ELP. Therefore, this article calculated the required IOL power for accurate implantation based on the actual refractive outcomes post-surgery. This is the first time that IOL power has been included as a relevant factor in the analysis. The scatter plot distribution of the back-calculated IOL power inversely corresponds to the AL. The overall trend shows that both high and low back-calculated IOL power exhibit good actual near-add power, while regular back-calculated IOL power is closest to the theoretical values provided by the manufacturer. Segmentation analysis also confirmed that when patients required the implantation of a higher base IOL power, the postoperative near-add power they actually achieved performed significantly better.

Pupil size changes the amount of light reaching the retina; therefore, small pupils can reduce the occurrence of optical aberrations and increase the DOF[34-38]. As a result, changes in pupil size may affect the outcomes of defocus curve assessment[39-40]. The study shows that no linear correlation was found between preoperative pupil size and PE. Segmental analyses also did not find statistically significant between the groups. The reason for these results may be due to the previous recommendations for pupil size screening in patients undergoing MIOLs implantation[41], which resulted in a smaller sample size of patients with small and large pupils in this study.

Previous studies have found that either astigmatic errors or HOAs would increase the depth of focus[42-44]. Patients with higher positive SA and against-the-rule astigmatism have been found to achieve satisfactory near vision after the implantation of monofocal IOLs[43,45-46]. To reduce the impact of postoperative astigmatism on postoperative vision, one of the inclusion criteria was that patients had predicted postoperative astigmatism ≤0.75 D, and in our sample, it was controlled at an average of 0.40 D. Additionally, the corneal SA and HOAs in our sample were controlled at averages of 0.26 and 0.16 mm, respectively. We considered that postoperative astigmatism, corneal SA, and HOAs within our sample were controlled in a small range, which had relatively little impact on the results of this study. Therefore, no further data were analyzed and investigated.

The research on actual near-add power in MIOLs is quite complex, with numerous related factors. This study has at least the following limitations: first, postoperative ACD is an important factor for evaluating ELP. The main aim of this study was to observe the predictive significance of preoperative biometric parameters for the actual postoperative near-add power. Therefore, we did not conduct any related research on postoperative ACD, which should be considered in future studies. Second, the results of the defocus curve are not entirely equivalent to near vision. During actual reading, a smaller object distance can lead to a reduced depth of focus. Additionally, there is anear reflex of the pupil during reading, which can cause changes in pupil size and may affect the results. Third, due to the preoperative patient selection process, the distribution of patients across the groups was not uniform, which may decrease the reliability of the results. In the future, increasing the sample size could further validate the findings.

In summary, the results of this study indicate that most patients can achieve an actual near-add power higher than the theoretical predictions provided by the manufacturer. Patients with normal AL and corneal power showed postoperative actual near-add power that was closest to the theoretical values. In special segments such as patients with AL of less than 22 mm and those between 26–28 mm, the actual near-add power after surgery is better. Additionally, patients with K in the 45–46 D range, patients with LT of over 4.5 mm, and patients who required the implantation of a base IOL power higher than 25 D exhibited better performance in actual near-add power. These findings demonstrate certain discrepancies compared to the theoretical values derived from IOL calculation formulas in previous studies, suggesting that these factors should be prioritized as key references for preoperative evaluation and prediction.

ACKNOWLEDGEMENTS

Authors' Contributions: Ye XY and Hu YF contributed to the

concept and design of the study. Hu YF and Wang Y performed the acquisition of data. Hu YF and Wang Y analyzed and interpreted the data. Hu YF drafted the manuscript. Hu YF, Wang Y, and Zhang R provided critical revisions of the manuscript for important intellectual content. Hu YF and Zhang R conducted the statistical analysis. Administrative, technical, or material support was provided by Wang Z and Ye XY. All authors contributed to the article and approved the submitted version.

Availability of Data and Materials: The data used and analyzed in this study are available from the corresponding author upon reasonable request.

Foundation: Supported by the Fuzhou Science and Technology Program (No.2023-S-005).

Conflicts of Interest: Hu YF, None; **Wang Y,** None; **Zhang R,** None; **Wang Z,** None; **Ye XY,** None.

REFERENCES

1 Alio JL, Simonov A, Plaza-Puche AB, *et al*. Visual outcomes and accommodative response of the lumina accommodative intraocular lens. *Am J Ophthalmol* 2016;164:37-48.

2 Hovanesian JA, Jones M, Allen Q. The vivity extended range of vision IOL vs the PanOptix trifocal, ReStor 2.5 active focus and ReStor 3.0 multifocal lenses: a comparison of patient satisfaction, visual disturbances, and spectacle independence. *Clin Ophthalmol* 2022;16:145-152.

3 Schallhorn JM, Pantanelli SM, Lin CC, *et al*. Multifocal and accommodating intraocular lenses for the treatment of presbyopia: a report by the American academy of ophthalmology. *Ophthalmology* 2021;128(10):1469-1482.

4 Sugawara K, Ito R, Horiguchi H, *et al*. Surgical outcome comparisons of multifocal IOLs of lentis comfort LS-313 MF15 and tecnis eyhance DIB00V. *Int J Ophthalmol* 2023;16(12):2004-2010.

5 Azor JA, Vega F, Armengol J, *et al*. Optical assessment and expected visual quality of four extended range of vision intraocular lenses. *J Refract Surg* 2022;38(11):688-697.

6 Yang CM, Lim DH, Hwang S, *et al*. Prospective study of bilateral mix-and-match implantation of diffractive multifocal intraocular lenses in Koreans. *BMC Ophthalmol* 2018;18(1):73.

7 Savini G, Hoffer KJ, Lombardo M, *et al*. Influence of the effective lens position, as predicted by axial length and keratometry, on the near add power of multifocal intraocular lenses. *J Cataract Refract Surg* 2016;42(1):44-49.

8 Serdiuk V, Ustymenko S, Fokina S, *et al*. Comparison of three different presbyopia-correcting intraocular lenses. *Rom J Ophthalmol* 2020;64(4):364-379.

9 Holladay JT, Hoffer KJ. Intraocular lens power calculations for multifocal intraocular lenses. *Am J Ophthalmol* 1992;114(4):405-408.

10 Hu YF. Actual near-add power in multifocal intraocular lenses. *Mendeley Data* 2024.

11 Kohnen T, Lemp-Hull J, Suryakumar R. Defocus curves: focusing on factors influencing assessment. *J Cataract Refract Surg* 2022;48(8):961-968.

12 Goggin M, Moore S, Esterman A. Outcome of toric intraocular lens implantation after adjusting for anterior chamber depth and intraocular lens sphere equivalent power effects. *Arch Ophthalmol* 2011;129(8):998-1003.

13 Eom Y, Kang SY, Song JS, *et al*. Effect of effective lens position on cylinder power of toric intraocular lenses. *Can J Ophthalmol* 2015;50(1):26-32.

14 Eom Y, Song JS, Kim HM. Spectacle plane add power of multifocal intraocular lenses according to effective lens position. *Can J Ophthalmol* 2017;52(1):54-60.

15 Lei Q, Tu HX, Feng X, *et al*. Distribution of ocular biometric parameters and optimal model of anterior chamber depth regression in 28, 709 adult cataract patients in China using swept-source optical biometry. *BMC Ophthalmol* 2021;21(1):178.

16 Tanaka T, Nishitsuka K, Obata H. Correlation of ocular biometry with axial length in elderly Japanese. *Clin Ophthalmol* 2024;18:351-360.

17 Haddad JS, Rocha KM, Yeh K, *et al*. Lens anatomy parameters with intraoperative spectral-domain optical coherence tomography in cataractous eyes. *Clin Ophthalmol* 2019;13:253-260.

18 Meng JQ, Fang YW, Lian JC, *et al*. Visual and patient-reported outcomes of a diffractive trifocal intraocular lens in highly myopic eyes: a prospective multicenter study. *Eye Vis* (*Lond*) 2023;10(1):19.

19 Castro C, Ribeiro B, Couto IMC, *et al*. Long-term refractive outcomes and visual quality of multifocal intraocular lenses implantation in high myopic patients: a multimodal evaluation. *Clin Ophthalmol* 2024;18:365-375.

20 Hua S, Xie QX, Wang H, *et al*. Effectivity and safety of trifocal intraocular lenses and capsular tension rings implantation for cataract patients with axial high myopia. *Int J Ophthalmol* 2024;17(3):499-508.

21 Wang B, Ciuffreda KJ. Depth-of-focus of the human eye: theory and clinical implications. *Surv Ophthalmol* 2006;51(1):75-85.

22 Burns DH, Allen PM, Edgar DF, *et al*. A review of depth of focus in measurement of the amplitude of accommodation. *Vision (Basel)* 2018;2(3):37.

23 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.

24 Zhang CG, Dai GZ, Pazo EE, *et al*. Accuracy of intraocular lens calculation formulas in cataract patients with steep corneal curvature. *PLoS One* 2020;15(11):e0241630.

25 Xu JL, Zhang L, Mo E, *et al*. The effect of corneal power on the accuracy of 14 IOL power formulas. *BMC Ophthalmol* 2024;24(1):126.

26 Zhang R, Hu YF, Wang Y, *et al*. Distribution and related factors analysis on corneal refractive power in cataract patients. *Yan Ke Xue Bao* 2023;38(12):837-844.

27 Ning XN, Yang YH, Yan H, *et al*. Anterior chamber depth—a predictor of refractive outcomes after age-related cataract surgery. *BMC Ophthalmol* 2019;19(1):134.

28 Hipólito-Fernandes D, Luís ME, Serras-Pereira R, *et al*. Anterior chamber depth, lens thickness and intraocular lens calculation formula accuracy: nine formulas comparison. *Br J Ophthalmol* 2022;106(3):349-355.

29 Yuan HR, Zhang JQ, Han XT, *et al*. Accuracy of 11 intraocular lens calculation formulas in shallow anterior chamber eyes. *Acta Ophthalmol* 2024;102(5):e705-e711.

30 Memarzadeh F, Tang ML, Li Y, *et al*. Optical coherence tomography assessment of angle anatomy changes after cataract surgery. *Am J Ophthalmol* 2007;144(3):464-465.

31 Olsen T. Prediction of intraocular lens position after cataract extraction. *J Cataract Refract Surg* 1986;12(4):376-379.

32 Olsen T, Hoffmann P. C constant: new concept for ray tracing-assisted intraocular lens power calculation. *J Cataract Refract Surg* 2014;40(5):764-773.

33 Lin HY, Kao ST, Chen S, *et al*. Comparing clinical outcomes of Optiwave Refractive Analysis, Lenstar, and surgeon's modified method for intraocular lens power calculation in Asian eyes. *Sci Rep* 2023;13(1):14447.

34 Breyer DRH, Kaymak H, Ax T, *et al*. Multifocal intraocular lenses and extended depth of focus intraocular lenses. *Asia Pac J Ophthalmol* (*Phila*) 2017;6(4):339-349.

35 Mathôt S. Pupillometry: psychology, physiology, and function. *J Cogn* 2018;1(1):16.

36 Petermeier K, Frank C, Gekeler F, *et al*. Influence of the pupil size on visual quality and spherical aberration after implantation of the Tecnis 1-piece intraocular lens. *Br J Ophthalmol* 2011;95(1):42-45.

37 Giménez-Calvo G, Bartol-Puyal FA, Altemir I, *et al*. Influence of ocular biometric factors on the defocus curve in an enlarged depth-of-focus intraocular lens. *Int Ophthalmol* 2023;43(3):945-955.

38 Messias A, Ferreira M, Mendonça GC, *et al*. Influence of pupillary dynamics on the defocus curve of eyes implanted with diffractive multifocal lenses: a randomized study. *Arq Bras Oftalmol* 2021;84(3):214-219.

39 Charman WN. Pinholes and presbyopia: solution or sideshow? *Ophthalmic Physiol Opt* 2019;39(1):1-10.

40 Del Águila-Carrasco AJ, Alarcon A, Weeber H, *et al*. Prediction of monocular defocus curves in pseudophakia with different pupil sizes. *Biomed Opt Express* 2025;16(2):709-717.

41 de Vries NE, Webers CAB, Touwslager WRH, *et al*. Dissatisfaction after implantation of multifocal intraocular lenses. *J Cataract Refract Surg* 2011;37(5):859-865.

42 Stark LR, Strang NC, Atchison DA. Dynamic accommodation response in the presence of astigmatism. *J Opt Soc Am A Opt Image Sci Vis* 2003;20(12):2228-2236.

43 Rocha KM, Gouvea L, Waring GO 4th, *et al*. Static and dynamic factors associated with extended depth of focus in monofocal intraocular lenses. *Am J Ophthalmol* 2020;216:271-282.

44 Stodulka P, Pracharova Z. Evaluation of extended depth-of-focus hydrophobic intraocular lens with an optic concept based on combination of high-order aberrations. *Ther Adv Ophthalmol* 2023;15:25158414231200108.

45 Hickenbotham A, Tiruveedhula P, Roorda A. Comparison of spherical aberration and small-pupil profiles in improving depth of focus for presbyopic corrections. *J Cataract Refract Surg* 2012;38(12):2071-2079.

46 Yamamoto T, Hiraoka T, Oshika T. Apparent accommodation in pseudophakic eyes with refractive against-the-rule, with-the-rule and minimum astigmatism. *Br J Ophthalmol* 2016;100(4):565-571.