

Comparing the Accuracy of Toric Intraocular Lens Calculations Between the IOLMaster 700 and iTrace

Andi Superceanu

University of Alberta

Matt Holzer

University of Alberta

Christoph Richard

FAU Erlangen-Nürnberg

Hermína Strungaru

strungar@ualberta.ca

University of Alberta

Research Article

Keywords: IOL master, iTrace, cataract, toric intraocular lens

Posted Date: July 5th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-10101390/v1>

License:  This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Additional Declarations: No competing interests reported.

Abstract

Background: To compare the accuracy of the IOLMaster 700 (IOLM) and iTrace in predicting postoperative astigmatism after cataract surgery with toric intraocular lens implantation.

Methods: The study was a single-center, prospective, observational study. It

included patients who underwent toric intraocular lens (IOL) insertion during uncomplicated cataract surgery by a single surgeon. Preoperative corneal astigmatism was measured using the IOLM and iTrace. The predicted error in residual astigmatism was calculated by vector analysis according to the calculation methods and the measurements used.

Results: A total of 217 eyes of 165 patients were included. The mean absolute astigmatism prediction errors were 0.47 ± 0.33 D and 0.49 ± 0.34 D for the IOLM and iTrace respectively ($p=0.047$) and the centroid of the prediction errors were 0.09 D @ 172 and 0.09 D @ 173 ($p=0.97$ for x-axis and $p=0.91$ for y-axis). In the with-the-rule subgroup, the mean absolute prediction errors were 0.50 ± 0.30 D and 0.51 ± 0.31 D for the IOLM and iTrace, respectively ($p=0.56$). In the against-the-rule subgroup, the mean absolute prediction errors were 0.42 ± 0.34 D and 0.45 ± 0.35 D. IOLM showed better results compared with iTrace in predicting post-operative astigmatism after cataract surgery. For the IOLM and iTrace, respectively ($p=0.06$). The IOLM yielded the best result with 62.7% <0.5 D prediction error in the total group and 70.2% in the against-the-rule subgroup.

Conclusions: IOLM showed better results compared with iTrace in predicting post-operative astigmatism after cataract surgery.

Background

Cataracts are the world's leading cause of blindness, affecting approximately 17.2% of adults over forty with significantly higher prevalence in the elderly.¹ Cataract surgery rates have increased over the past twenty years in North America² with more than 50% of patients over seventy-five requiring it.³ The surgery improves vision,⁴ lowers the risk of falls,⁵ and reduces financial strain on patients and healthcare systems.⁶

Cataract surgery is also increasingly being used to correct astigmatism. Almost half of the population over sixty years has one diopter or more of astigmatism, causing meaningful visual impairment.^{7,8} Toric intraocular lenses (IOLs) implanted during cataract surgery go beyond standard IOLs by correcting astigmatism and are increasingly being used.⁹ Despite being more expensive than standard lenses, toric lenses reduce lifetime costs to correct vision since many patients do not require glasses following the procedure.^{10,11}

Choosing an appropriate toric IOL relies on precise measurement of the preoperative corneal astigmatism.^{12–16} Currently, no gold-standard exists to measure total corneal astigmatism, however the

IOLM (Carl Zeiss Meditec AG, Jena, Germany) yields accurate and consistent measurements when compared with other devices¹⁷. The IOLM is a widely used swept-source biometer which provides high accuracy and repeatability¹⁷, directly measuring the anterior and posterior cornea. The iTrace by Tracey Technologies Corp is a newer device which employs ray tracing aberrometry and corneal topography¹⁸ and measures the anterior corneal astigmatism. While both machines can perform keratometry measurements, they are different in purpose and technology¹⁸. These differences raise the question of which machine is better in prediction of toric IOL implantation outcomes. Previous studies comparing the keratometry between the IOLM and iTrace have shown mixed results of measurement agreements¹⁸. A consistent finding is that the keratometry measurements from these machines cannot be used interchangeably^{19,20}, however, we do not know which machine is more accurate in toric calculations in astigmatic cataract surgery patients.

To the best of our knowledge, our study is the first to compare toric calculations based on IOLM and iTrace keratometry with postoperative visual outcomes to see which device provides better predictions.

Methods

This prospective study followed the Declaration of Helsinki and was approved by the University of Alberta Research Ethical Board, application number Pro00133635. We enrolled cataract patients at Eye Physicians and Surgeons (Edmonton, Alberta) between October 1st, 2023, and March 30th, 2024, who (i) were eighteen or older, (ii) had regular corneal astigmatism between 0.75–5.0 D, (iii) elected toric IOL implantation, (iv) had otherwise healthy eyes excluding astigmatism and cataracts, and (v) provided informed consent. We excluded patients with prior ocular disease or surgery, irregular astigmatism, intraoperative complications, or patients who wore contact-lenses within two weeks of preoperative measurements.

All patients underwent standard examinations, with keratometry assessments performed by one of two experienced technicians. Ocular biometry was measured using the IOLM before using any eye drops or performing any contact-based examination. Corneal measurements with the iTrace were performed in a dark room with an undilated pupil.

IOL spherical equivalent power was based on measurements from the IOLM using the Barrett Universal[®] formula, and IOL cylinder power was based using the keratometry entry from IOLM and imputed into the Johnson and Johnson Toric IOL online Calculator (<https://tecnistoriccalc.com/>). Keratometry data from the iTrace was recorded and entered into the same Johnson and Johnson Toric IOL Calculator to produce a theoretical IOL cylinder power and axis. This theoretical IOL calculation was not used for actual surgery, but only for simulating the replacement of the inserted IOL and acquiring a new postoperative refractive outcome for vector analysis. The surgical induced astigmatism (SIA) for the toric IOL calculation was 0.25 D at 180° in the right eye and 0° for the left eye, calculated based on the surgeon's historical personalized results.

Cataract surgery was performed by a single surgeon in Edmonton zone public hospitals by administering topical anesthesia, and by making 2.4-mm bi-beveled keratome scleral–limbal incisions at 180° for the right eye and 0° for the left eye and with “divided and conquer” phacoemulsification. All eyes had in-the-bag implantation of a Johnson and Johnson (Johnson and Johnson Vision, Markham, Ontario, Canada) one-piece hydrophobic acrylic IOL, either ZCU or DIU models. At the postoperative visit, the orientation of the IOL was recorded and any eye with an IOL oriented more than 10° from intended was excluded from the final dataset. Patients were required to see an optometrist during the six-week follow-up appointment, who reported back the uncorrected (UCVA) and best corrected visual acuity (BCVA), and objective and subjective refraction.

Analysis of postoperative visual data was done using vector addition as described by Holladay *et al*²¹. When comparing the predictions made preoperatively with the postoperative refraction, the vector analysis was performed using the values from the manifest refraction with vertex to the cornea. When comparing the actual and predicted postoperative refraction, the actual postoperative refractive astigmatism was calculated by vertexing the postoperative manifest refractive astigmatism to the corneal plane. The predicted postoperative refractive astigmatism for each machine was calculated using the preoperative keratometry measurements from both biometers, the IOLM and iTrace, and the intended IOL power, cylinder, and axis were based on the Johnson and Johnson Toric IOL online Calculator (<https://tecnistoriccalc.com/>) using predicted posterior astigmatism. The postoperative refractive astigmatism prediction error was then calculated as the vector difference between the actual and predicted postoperative refractive astigmatism. The mean of the absolute prediction error (MAE), the standard deviation (SD) of the absolute prediction error, the centroid of the prediction error, the total standard deviation of the prediction error, as well as the proportion of eyes within a prediction error of 0.50 D, 0.75 D, and 1.00 D were calculated.

We performed a subgroup analysis based on the orientation of the anterior corneal astigmatism. Eyes were considered to have against-the-rule (ATR) astigmatism when the anterior corneal steep meridian was between 0° and 30° or 150° and 180°, with-the-rule (WTR) astigmatism when the anterior corneal steep meridian was between 60° and 120°, and oblique astigmatism in all others. The same vector analysis was performed in each subgroup of astigmatism type.

Our statistical data analysis follows the recent recommendations of the Journal of Cataract and Refractive Surgery^{22, 23}. We used the Rallfun-v45 version of the Wilcox-Holladay-Wang-Koch (WHWK) Statistical Software, as described in detail previously²⁷. For all statistical tests, we chose a significance level $\alpha = 0.05$ for a type I error. The pairs of p-values given in the mean centroid are non-adjusted p-values for the x coordinate and for the y coordinate of the centroid, respectively, as provided by the WHWK statistical software. For the ≤ 0.50 D (%), the intervals are 95% BCA-bootstrap confidence intervals for the difference in percent as computed with the R package boot, version 1.3–32; here a difference is significant if 0 is outside the confidence interval.

Results

We included a total of 217 eyes from 165 patients, WTR astigmatism was present in 56 eyes (25.8%), ATR astigmatism was present in 124 eyes (57.14%) and oblique astigmatism was found in 37 eyes (17.06%). Table 1 shows the baseline demographics and biometry data of the studied group. IOL power and lens type implanted are shown in Fig. 1A. The most common IOL cylinder power used was 150 followed by 100. The comparison of the IOL cylinder power recommendations calculated between the IOLM and iTrace showed 58.08% of eyes requiring the same corrective cylinder power, and 95.77% of eyes within one power difference (Fig. 1B).

Table 1
Baseline demographics of the study patients

Parameters	Number/Average $\pm$ SD (Range)
Age (years)	70.97 $\pm$ 7.96 (44–89)
Gender (F/M)	100/65
Eyes, n = 217 (OD/OS)	109/108
Axial length (mm)	24.49 $\pm$ 1.53 (20.28–28.72)
Anterior chamber depth (mm)	3.23 $\pm$ 0.40 (2.16–4.12)
Lens used (DIU/ZCU)	155/61
Implanted IOL power (D)	18.00 $\pm$ 4.7 (5.00–34.00)
Eyes with WTR astigmatism (n)	56
Eyes with ATR astigmatism (n)	124
Eyes with oblique astigmatism (n)	37
Kflat IOLM -K1 (D)	43.35 $\pm$ 1.54 (39.91–47.89)
Ksteep IOLM -K2(D)	44.74 $\pm$ 1.63 (40.9–50.56)
Kflat iTrace -K1 (D)	43.04 $\pm$ 1.45 (39.85–47.58)
Ksteep iTrace-K2 (D)	44.34 $\pm$ 1.59 (40.91–49.84)
OD right eye, OS left eye, IOL- intraocular lens implant, D-diopters, ATR = against-the-rule; D = diopter; SD = standard deviation; WTR = within-the-rule. Data presented as n or mean absolute average $\pm$ SD. Ranges are shown in parentheses.	

Figure 2 shows the double-angle plots of the preoperative corneal astigmatism and the postoperative refractive astigmatism and the cumulative histogram of the amount of preoperative corneal astigmatism compared with the postoperative refractive astigmatism. The percentage of eyes within a prediction error of ± 0.50 D, ± 0.75 D, and ± 1.00 D are shown in Fig. 3. Figure 4 shows the double-angle plots of the prediction error for each machine, 4A for total eyes, 4B for the WTR eyes, 4C for ATR and 4D for oblique groups respectively. Table 2 presents the overall clinical outcomes for each machine. There was a significant difference in MAEs in the prediction error between the two machines ($p = 0.047$), where the

IOLM showed a better prediction value than iTrace. The centroid of the prediction error was close to zero for both machines and it was not statistically significant between the two machines ($p = 0.97$ for x-axis and $p = 0.91$ for y-axis). The IOLM yielded statistically significant better results with 62.7% $\leq 0.5D$ prediction error, compared with 56.2% for iTrace (95% CI (1.8, 10.6)).

Table 2
Clinical outcomes for each machine

Machine	MAE	MedAE	Mean centroid (diopters @ degrees) $\pm$ SD	$\leq 0.50 D$ (%)
IOLM (total, n = 217)	0.47	0.39	0.09 D @172 $\pm$ 0.57 D	62.7
iTrace (total, n = 217)	0.49	0.42	0.09 D @173 $\pm$ 0.59 D	56.2
P	0.047*		0.97 (x-axis), 0.91 (y-axis)	95% CI (1.8, 10.6)*
IOLM (WTR, n = 56)	0.50	0.43	0.35 D @91 $\pm$ 0.47 D	58.9
iTrace (WTR, n = 56)	0.51	0.46	0.32 D @92 $\pm$ 0.51 D	55.3
P	0.56		0.56 (x-axis), 0.57 (y-axis)	95% CI (-7.1, 12.5)
IOLM (ATR, n = 124)	0.42	0.33	0.30 D @2 $\pm$ 0.45 D	70.2
iTrace (ATR, n = 124)	0.45	0.38	0.29 D @3 $\pm$ 0.49 D	62.1
P	0.062		0.60 (x-axis), 0.63 (y-axis)	95% CI (2.4, 12.9) *
IOLM (Oblique, n = 37)	0.61	0.55	0.22 D @143 $\pm$ 0.65 D	43.2
iTrace (Oblique, n = 37)	0.63	0.63	0.21 D @143 $\pm$ 0.68 D	37.8
P	0.50		0.97 (x-axis), 0.90 (y-axis)	95% CI (-5.4, 13.5)
ATR=against the rule, MAE=mean absolute prediction error, MedAE=median absolute prediction error, SD=standard deviation, WTR=with the rule.				
*Statistically significant				

When the orientation of anterior corneal astigmatism subgroups was analyzed, there was no significant difference in MAEs and the centroid prediction error between the two machines ($p > 0.05$). The IOLM yielded the best results in the ATR subgroup with 70.2% $\leq 0.5D$ prediction error compared with 62.1% in iTrace group (95% CI (2.4, 12.9)).

Discussion

Despite our best efforts to minimize unexpected residual astigmatism after cataract surgery, most cataract surgeons attain an accuracy within ± 0.50 D in 78% of patients, with only 1% of surgeons reaching 92% accuracy²⁴. Reliable and accurate preoperative corneal astigmatism measurements are crucial for toric lens implantation. Inaccurate measurements may result in failure of astigmatism correction or even worsen postoperative corneal astigmatism. Finding more accurate and reliable measurements will improve the outcome of residual refractive error after cataract surgery.

This study compared the accuracy and reliability of toric IOL calculations between two machines, the IOLM and iTrace, using their keratometry measurements. To the best of our knowledge, this is the first study directly comparing the two machines' preoperative toric predictions using real post-operative outcomes. The present study showed IOLM measurements resulted in more accurate and better outcomes than iTrace measurements. The prediction error of ≤ 0.5 D was found to be in 62.7% of eyes measured with IOLM and 56.2% of eyes measured with iTrace being statistically significant (95% CI (1.8, 10.6)). These results are plausible because the intraocular lens suggested by IOLM was always inserted. The difference in prediction errors between the two machines are not related to direct measurements of posterior curvature. In our study, we used anterior values of keratometry measured by IOLM and Johnson and Johnson online calculator with predicted posterior astigmatism to equalize the two machines in measuring the total corneal astigmatism. The mean absolute error (MAE) was used to investigate the accuracy of IOL calculations. The MAE was statistically significantly different between the two machines with an MAE of 0.47 for IOLM and 0.49 for iTrace ($p = 0.047$). The results showed that the IOLM is better than the iTrace in accuracy of toric IOL calculations. The centroid of prediction errors in our study was similar between IOLM (0.09 D @172) and iTrace (0.09 @ 173), which was not statistically significant ($p = 0.97$ for x-axis and $p = 0.91$ for y-axis). Our study showed one of the lowest centroid prediction errors reported in the literature. Previous studies^{15-16, 25-27} which included direct measurements of posterior corneal curvature such as Scheimpflug imaging systems (Pentacam and Galilei Dual analyzer) and swept-source optical coherence tomography (IOL Master 700) showed a centroid prediction error ranging from 0.09 D to 0.64 D.

Our study also analyzed clinical outcomes in subgroups based on the orientation of anterior corneal astigmatism. The prediction error of ≤ 0.5 D was found to be the highest in ATR in 70.2% of eyes measured with IOLM. Previous studies^{15-17, 28} looking at the correlation between prediction errors and subgroups of astigmatism had controversial results. Yang et al.¹⁶ showed the highest prediction error of ≤ 0.5 D in WTR subgroup (65.9%), however this study used only IOLM measurements to compare different types of formulas. Ho et al.¹⁵ did not show any significant WTR/ATR prediction error differences in WTR or ATR eyes; on the other hand, Koch et al.²⁸ showed a significant WTR prediction error of 0.57 D in WTR eyes, while the ATR astigmatism was fully corrected. The MAE and centroid prediction errors of all subgroups were very similar in our study, and not statistically significant between the IOLM and iTrace. Yang et al.¹⁶ had comparable results in IOLM measurements with no statistical significance in MAE

values subgroups, however, they showed a lower MAE across all the subgroups than in our study (0.22 D). The lowest centroid values of the prediction value in our study were in oblique astigmatisms, 0.22 D @143 for the IOLM, and 0.21 D @143 for the iTrace. Yang et al.¹⁶ showed a centroid error in the WTR astigmatism subgroup closer to 0 compared with those in the ATR astigmatism subgroup (0.9 D versus 0.22 D).

While our prospective study design has robust inclusion criteria and large sample size, this study has some limitations. One such limitation is a lack of generalizability to other patient populations due to the data being collected from a single center. Additionally, our exclusion of complex cases suggests that our findings may not apply to irregular-astigmatism cases. A follow-up time of six weeks could also miss long term astigmatic shifts or lens position changes. Furthermore, this study only evaluated the toric lenses from Johnson and Johnson and therefore excluded other types of lenses. In the current study, always the lens suggested by IOLM is inserted. It is thus expected that IOLM predicts no worse than iTrace. Future research should include multi-center studies with a more diverse population, longer follow-ups, intraocular lens inserted by iTrace calculations and diverse IOL types.

Declarations

Ethics approval and consent to participate

This prospective study followed the Declaration of Helsinki and was approved by the University of Alberta Research Ethical Board, application number Pro00133635.

All participants signed a written consent to participate in the study

Consent for publication

Not applicable

Availability of data and materials

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

Competing interests

The authors declare that they have no competing interests

Funding

No grant from the commercial, public, or non-profit sectors was received by this investigation.

Authors' contributions

Andi Superceanu collected data, interpreted the data and wrote the first version of manuscript.

Matt Holzer recruited patients involved in the study and collected a part of data.

Christoph Richard did the statistical analysis.

Marcela Hermina Strungaru provided the patients to be recruited, helped in collecting the data, interpreted data and wrote the final version of the manuscript.

Acknowledgements

Not applicable

References

1. Hashemi H, Pakzad R, Yekta A, Aghamirsalim M, Pakbin M, Ramin S, Khabazkhoob M. Global and regional prevalence of age-related cataract: a comprehensive systematic review and meta-analysis. *Eye*. 2020;34(8):1357-1370. doi:10.1038/s41433-020-0806-3
2. Klein B, Klein R, Lee K. Incidence of age-related cataract over a 10-year interval: the Beaver Dam Eye Study. *Ophthalmology*. 2002 Nov;109(11):2052-7. doi: 10.1016/s0161-6420(02)01249-6.
3. Congdon N, O'Colmain B, Klaver CCW, Klein R, Muñoz B, Friedman DS, Kempen JH, Taylor HR, Mitchell P; Eye Diseases Prevalence Research Group. Causes and prevalence of visual impairment among adults in the United States. *Arch Ophthalmol*. 2004;122(4):477-485. doi:10.1001/archopht.122.4.477
4. Lamoureux E L, Fenwick E, Pesudovs K, Tan D. The Impact of Cataract Surgery on Quality of Life. *Curr Opin Ophthalmol*. 2011;22(1):19–27. doi:10.1097/ICU.0b013e3283414284.
5. Harwood RH, Foss AJE, Osborn F, Gregson RM, Zaman A, Masud T. Falls and health status in elderly women following first-eye cataract surgery: a randomised controlled trial. *Br J Ophthalmol*. 2005;89(1):53-59. doi:10.1136/bjo.2004.049478.
6. Rein DB, Zhang P, Wirth KE, Lee PP, Hoerger TJ, McCall N, Klein R, Tielsch JM, Vijan S, Saaddine J. The economic burden of major adult visual disorders in the United States. *Arch Ophthalmol*. 2006;124(12):1754-1760. doi:10.1001/archopht.124.12.1754
7. Khan M, Muhtaseb M. Prevalence of corneal astigmatism in patients having routine cataract surgery at a teaching hospital in the United Kingdom. *J Cataract Refract Surg* 2011 Oct;37(10):1751-1755. doi: 10.1016/j.jcrs.2011.04.026
8. Guan Z, Yuan F, Yuan Y, Niu W, Tang X. Analysis of corneal astigmatism in cataract surgery candidates at a teaching hospital in Shanghai, China. *J Cataract Refract Surg*. 2012;38(11):1970-1977. doi:10.1016/j.jcrs.2012.07.025.
9. Goggin M. Toric intraocular lenses: Evidence-based use. *Clin Exp Ophthalmol*. 2022 May 29;50(5):481–489. doi: 10.1111/ceo.14106

10. Laurendeau C, Lafuma A, Berdeaux G. Modelling lifetime cost consequences of toric compared with standard IOLs in cataract surgery of astigmatic patients in four European countries. *J Med Econ*. 2009 Sep;12(3):230-237. doi: 10.3111/13696990903257439
11. Kessel L, Andresen J, Tendal B, Erngaard D, Flesner P, Hjortdal J. Toric intraocular lenses in the correction of astigmatism during cataract surgery: a systematic review and meta-analysis. *Ophthalmology*. 2016;123(2):275-286. doi:10.1016/j.ophtha.2015.10.002.
12. Li X, Cao X, Bao Y. Comparison of Total Corneal Astigmatism between IOLMaster and Pentacam. *Biomed Res Int*. 2022 Jul 8;2022:9236006. doi: 10.1155/2022/9236006
13. Potvin R, Kramer B, Hardten D, Berdahl J. Toric intraocular lens orientation and residual refractive astigmatism: an analysis. *Clin Ophthalmol*. 2016 Sep 20;10:1829–1836. doi: 10.2147/OPTH.S114118.
14. Yang Z, Zhou Y, Jin T, Li J. An evaluation of the accuracy of toric intraocular lens power calculation based on measured total corneal refractive power. *Indian J Ophthalmol* 2023 Feb;71(2):541-546. doi: 10.4103/ijo.IJO_1539_22.
15. Ho Y J, Sun C C, Lee J S, Lin K K, Hou C H. Comparison of using Galilei Dual Scheimpflug Analyzer G4 and Barrett formula in predicting low cylinder preoperatively for cataract surgeries. *Eur J Ophthalmol*. 2020;30(6):1320-1327. doi:10.1177/1120672119866068.
16. Yang S, Byun Y, Kim H, Chung S-H. Comparative accuracy of Barrett toric calculator with and without posterior corneal astigmatism measurements and the Kane toric formula. *Ophthalmol*. 2021 Nov; 231:48-57. doi: 10.1016/j.ajo.2021.05.028. Epub 2021 Jun 9. PMID: 34116010.
17. LaHood BR, Goggin M. Measurement of posterior corneal astigmatism by the IOLMaster 700. *J Refract Surg*. 2018;34(5):331–336.
18. Ashena Z, Gallagher S, Naveed H, Spalton DJ, Nanavaty MA. Comparison of anterior corneal aberrometry, keratometry and pupil size with Scheimpflug tomography and ray-tracing aberrometer. *Vision (Basel)*. 2022;6(1):18. doi:10.3390/vision6010018.
19. Hua Y, Xu Z, Qiu W, Wu Q. Precision (Repeatability and Reproducibility) and Agreement of Corneal Power Measurements Obtained by Topcon KR-1W and iTrace. *PLoS ONE*. 2016;11(1):e0147086. doi:10.1371/journal.pone.0147086.
20. Ma S, Li C, Sun J, Yang J, Wen K, Chen X, Zhao F, Sun X, Tian F. Assessing the interchangeability of keratometry measurements from four biometric devices in intraocular lens power calculations: insights into the predictive accuracy of five modern IOL formulas. *BMC Ophthalmol*. 2025;25(1):236. doi:10.1186/s12886-025-04067-y.
21. Holladay JT, Moran JR, Kezirian GM. Analysis of aggregate surgically induced refractive change, prediction error, and intraocular astigmatism. *J Cataract Refract Surg* 2001; 27:61 79. doi:10.1016/s0886-3350(00)00796-3.
22. Kohnen T, Næser K, Holladay JT, Stulting RD, Wang L, Abulafia A, Koch DD. Standards for analyzing astigmatic outcomes: Part I: astigmatism basics. *J Cataract Refract Surg*. 2025;51(6):440-446. doi:10.1097/j.jcrs.0000000000001644.

23. Koch DD, Holladay JT, Naeser K, Abulafia A, Wang L, Stulting RD, Kohnen T. Standards for analyzing astigmatic outcomes: Part II – recommended statistical methods. *J Cataract Refract Surg*. 2025;51(6):447-455. doi:10.1097/j.jcrs.0000000000001645.
24. Koch D, Hill W, Abulafia A, Wang Li. Pursuing perfection in intraocular lens calculations: I. Logical approach for classifying IOL calculation formulas. *J Cataract Refract Surg*. 2017 Jun;43(6):717-718. doi: 10.1016/j.jcrs.2017.06.006.
25. Canovas C, Alarcon A, Rosen R, Kasthurirangan S, Ma JJK, Koch DD, Piers P. New algorithm for toric intraocular lens power calculation considering the posterior corneal astigmatism. *J Cataract Refract Surg*. 2018;44(2):168-doi:10.1016/j.jcrs.2017.11.008.
26. Kane JX, Connell B. A comparison of the accuracy of 6 modern toric intraocular lens formulas. *Ophthalmology*. 2020;127(11):1472-1486doi:10.1016/j.optha.2020.04.039.
27. Skrzypecki J, Sanghvi Patel M, Suh LH. Performance of the Barrett toric calculator with and without measurements of posterior corneal curvature. *Eye (Lond)*. 2019;33(11):1762–1767. doi:10.1038/s41433-019-0489-9.
28. Koch DD, Jenkins RB, Weikert MP, Yeu E, Wang L. Correcting astigmatism with toric intraocular lenses: effect of posterior corneal astigmatism. *J Cataract Refract Surg*. 2013;39(12):1803-1809. doi:10.1016/j.jcrs.2013.06.027.

Figures

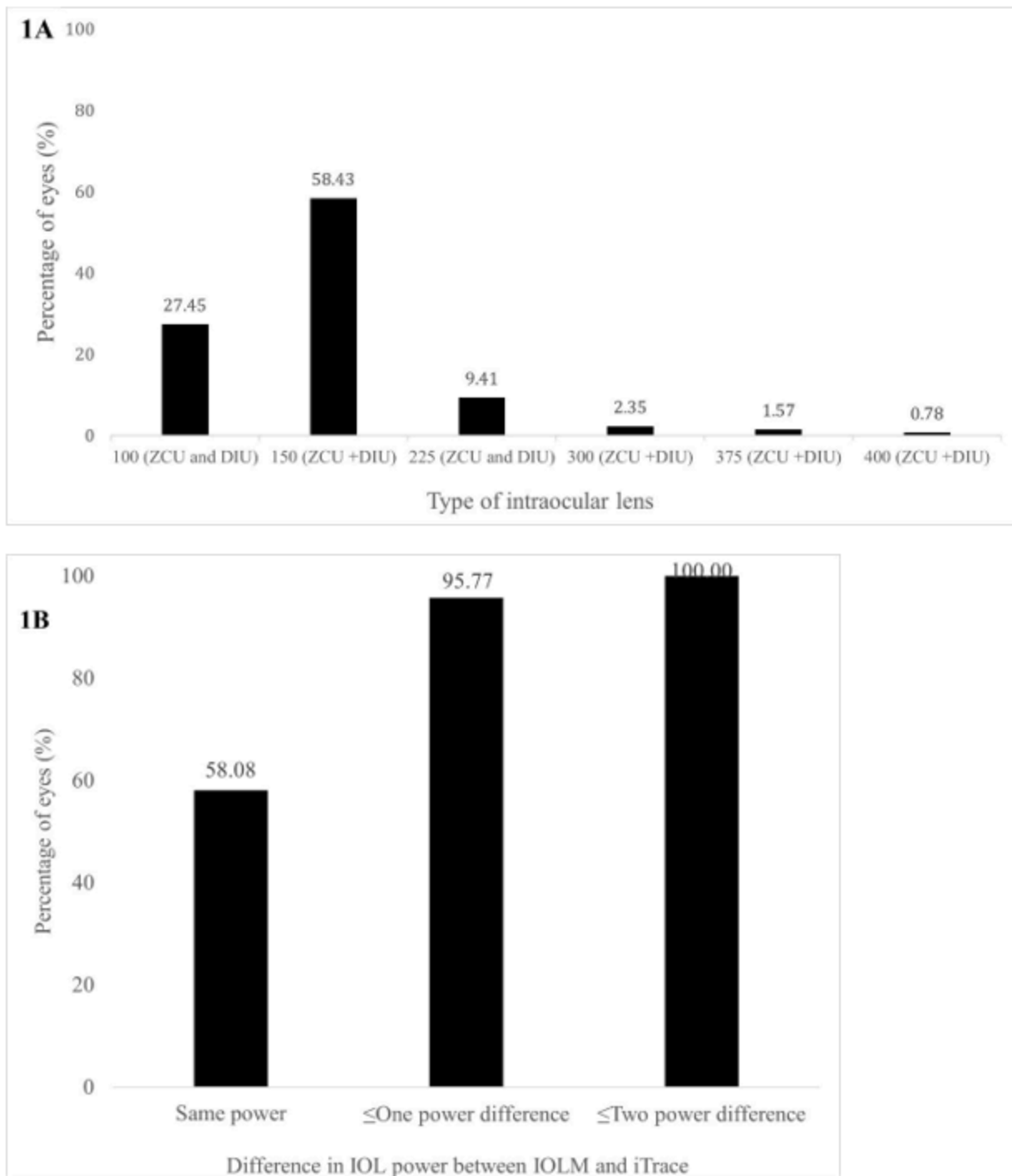


Figure 1

A. Type of Intraocular lens implants (IOL) implanted during cataract surgery and their respective powers.
B. Lens cylinder power recommendation differences between the IOLM vs iTrace biometry. Johnson and Johnson IOL toric powers were 100, 150, 225, 300, 375, and 400.

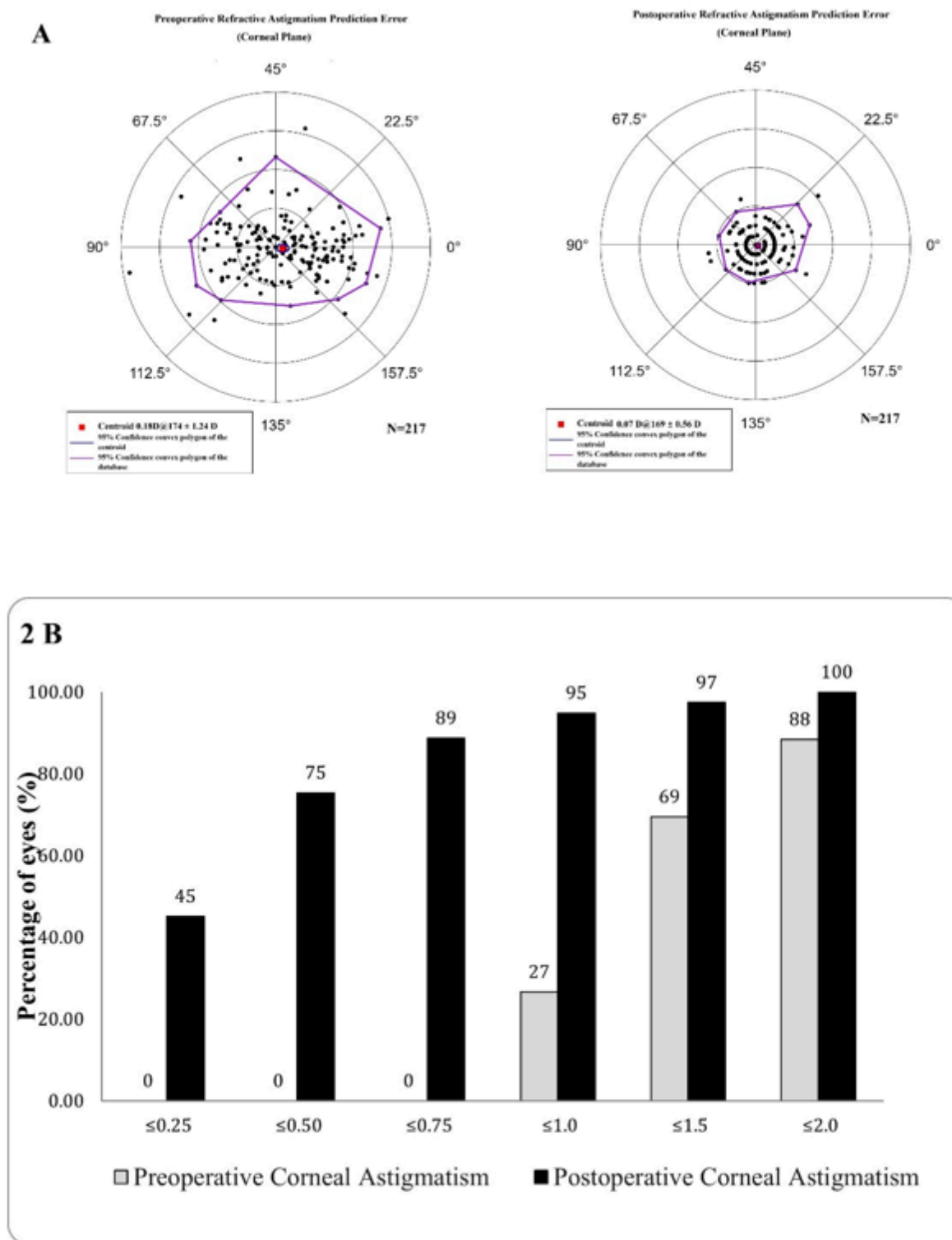
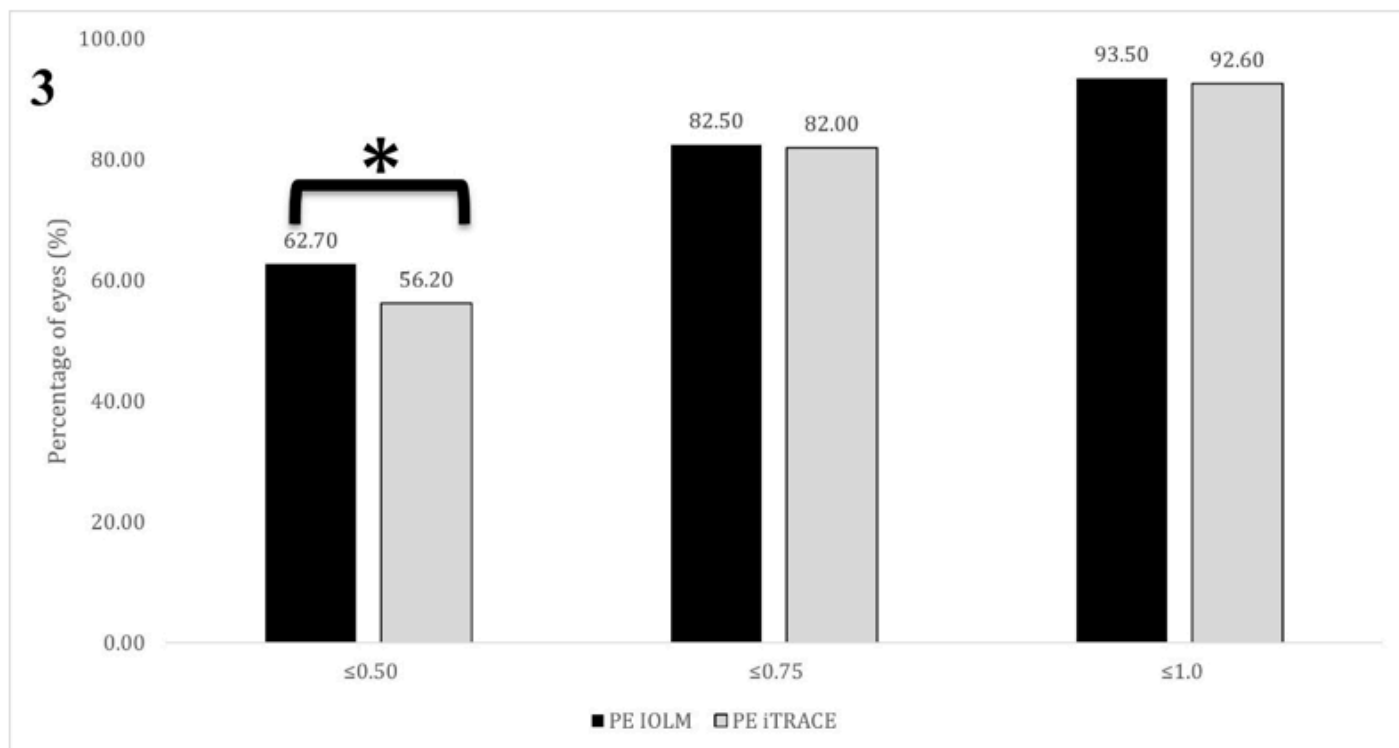


Figure 2

A. Double-angle plots of the preoperative and actual postoperative refractive astigmatism (vertex to cornea plane). **B.** Cumulative histogram of preoperative and actual postoperative refractive astigmatism. D = diopter.



Absolute prediction error (PE) %			
	IOLM	iTrace	95% CI
= 0.5 D	62.7	56.2	(1.8, 10.6)
= 0.75 D	82.5	82	(-4.1, 4.1)
= 1D	93.5	92.6	(-0.9, 2.3)

Figure 3

Histograms showing percentages of eyes with an absolute prediction error (PE) of ≤ 0.50 D, 0.75 D, and 1.00 D for each of the machines, IOLM and iTrace.* statistically significant.

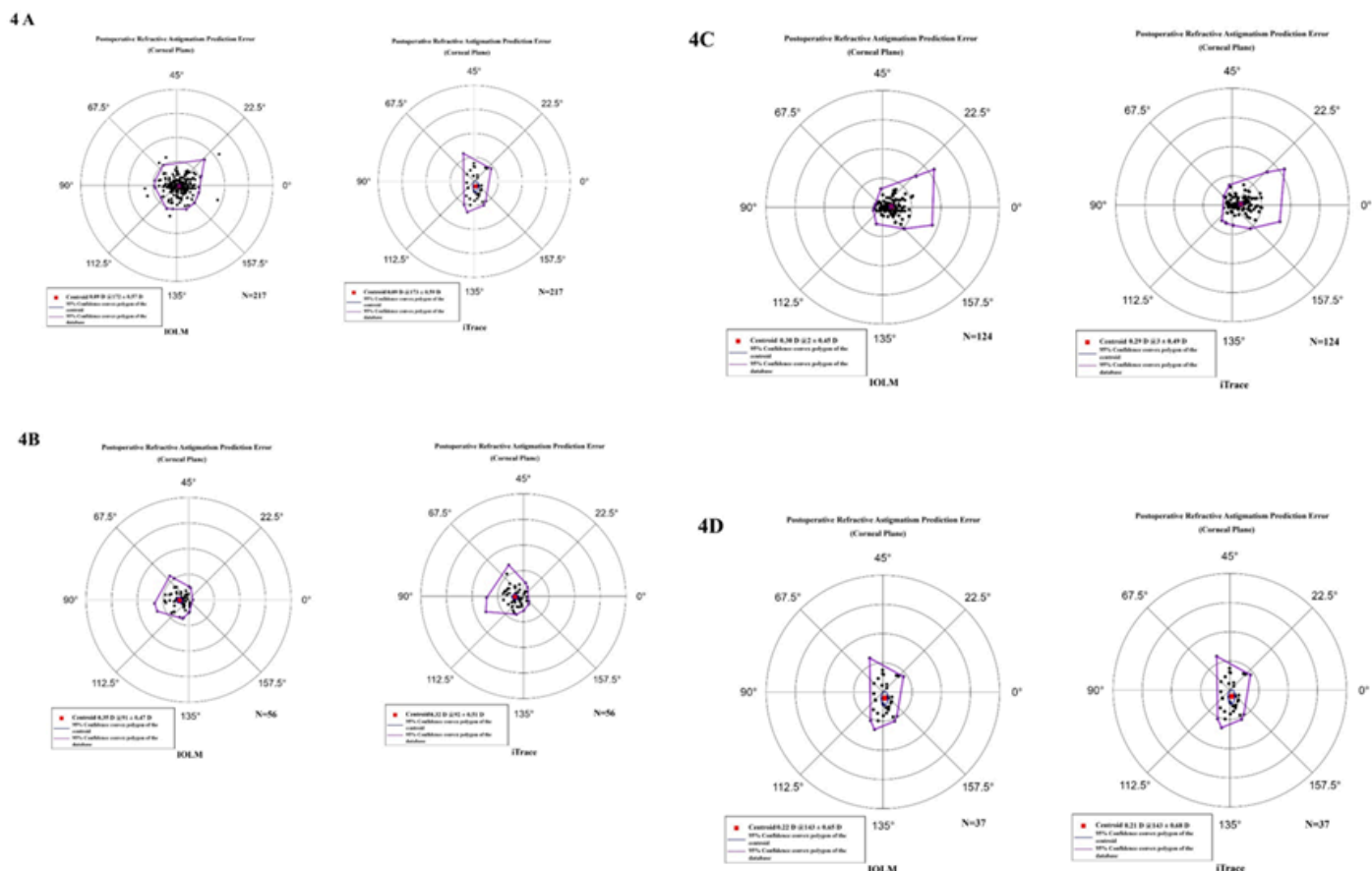


Figure 4

A. Double-angle plots of the prediction error for each machine in the total group (vertex to the cornea plane). **B.** Double-angle plots of the prediction error for each machine in the WTR group (vertex to the cornea plane). **C.** Double-angle plots of the prediction error for each machine in the ATR group (vertex to the cornea plane). **D.** Double-angle plots of the prediction error for each machine in the oblique group (vertex to the cornea plane).