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Keynote Lecture

New standards for analyzing astigmatic outcomes

Thomas Kohnen

Financial disclosure:
T. Kohnen: *Consultant and Research* for Alcon, J&J, Lensgen, Oculentis, Oculus, Presbia, Schwind, Zeiss. *Consultant for* Allergan, Bausch & Lomb, Geuder, Med Update, Santen, Staar, Thieme, Ziemer.

Department of Ophthalmology
Goethe University Frankfurt, Germany
Chair: Univ.-Prof. Dr. med. Thomas Kohnen, FEBO

FROM THE EDITOR

Setting standards for astigmatism analysis

Douglas D. Koch, MD, Thomas Kohnen, MD, PhD, FEBO

Astigmatism analysis is a complex topic. Analyzing astigmatic outcomes requires two elements: (1) scalar or nonvector analysis, since the magnitude of refractive astigmatism is a predictor of visual function, and (2) vector analysis, which, by recognizing that astigmatism is bivariate—that is, has magnitude and angle—is required to calculate astigmatic change. Stokes in 1849 was the first to recognize a fundamental principle of vector analysis of astigmatism. One must first double the angles to create vector values that enable correct analytical approaches.[1]

A large number of methods of analyzing astigmatic change have been proposed in recent years. Those that follow the principles of double-angle bivariate analysis are accurate and provide valuable insights. Unfortunately, some methods of analyzing astigmatic change are not valid because they do not adhere to these principles, resulting in misleading analyses that fail to advance the science. Further complicating this area is the recent recognition that astigmatic data are not normally distributed.[2] New statistical approaches that account for this are required and are now available.

To address these issues, the editors of the *Journal of Cataract & Refractive Surgery* initiated a working group to update and establish astigmatic reporting guidelines. The goal was to provide the basic elements of accurate reporting of astigmatic change, incorporating correct vector mathematics and statistical methodology. The guidelines are based on sound optical principles that avoid misleading results and allow authors, peer reviewers, and readers to easily understand, assimilate, and compare published reports of low-order astigmatic corrections.

Together with an international team of authors, we present the work in two parts. The first paper is an overview of astigmatism, including definitions, measurement technologies, and sources of error and variability (page ***). The second paper describes our recommended methodology for analyzing astigmatic outcomes (page ***). This approach is based on the optics of corneal and lenticular astigmatism, as well as contemporary vector analysis and statistical approaches. We want to emphasize that what we propose is not exclusive, that is, that authors may wish to provide additional valid analyses to better characterize their outcomes. We believe that implementing these analytical and statistical methods will bring accuracy, consistency, and clarity to astigmatism reporting.

REFERENCES

1. Stokes GG. 19th meeting of the British association for the advancement of science. Transactions of the sections, notices and abstracts of miscellaneous communications to the sections. On a Mode of Measuring the Astigmatism of a Defective Eye. 1849;10–11 (pub. 1850). Biodiversity Heritage Library. Accessed January 2, 2025. https://www.biodiversitylibrary.org/page/[illegible]#page/[illegible]/mode/1up
2. Holladay JT, Wilcox RR, Koch DD, Wang L. Astigmatism analysis and reporting of surgically induced astigmatism and prediction error. J Cataract Refract Surg. 2022;48(7):799-812. doi:10.1097/j.jcrs.[illegible]

Disclosures: *T. Kohnen is a consultant and conducts research for Alcon, Johnson & Johnson Vision, Lensgen, Oculentis, Oculus, Presbia, Schwind, and Carl Zeiss Meditec, and is a consultant for Allergan, Bausch & Lomb, Geuder, Med Update, Santen, Staar, Thieme, and Ziemer. D. Koch is a consultant for Alcon Laboratories, Carl Zeiss Meditec, and Johnson & Johnson Vision. T. Kohnen and D. Koch are co-authors of the articles under discussion (page *** and page ***).*

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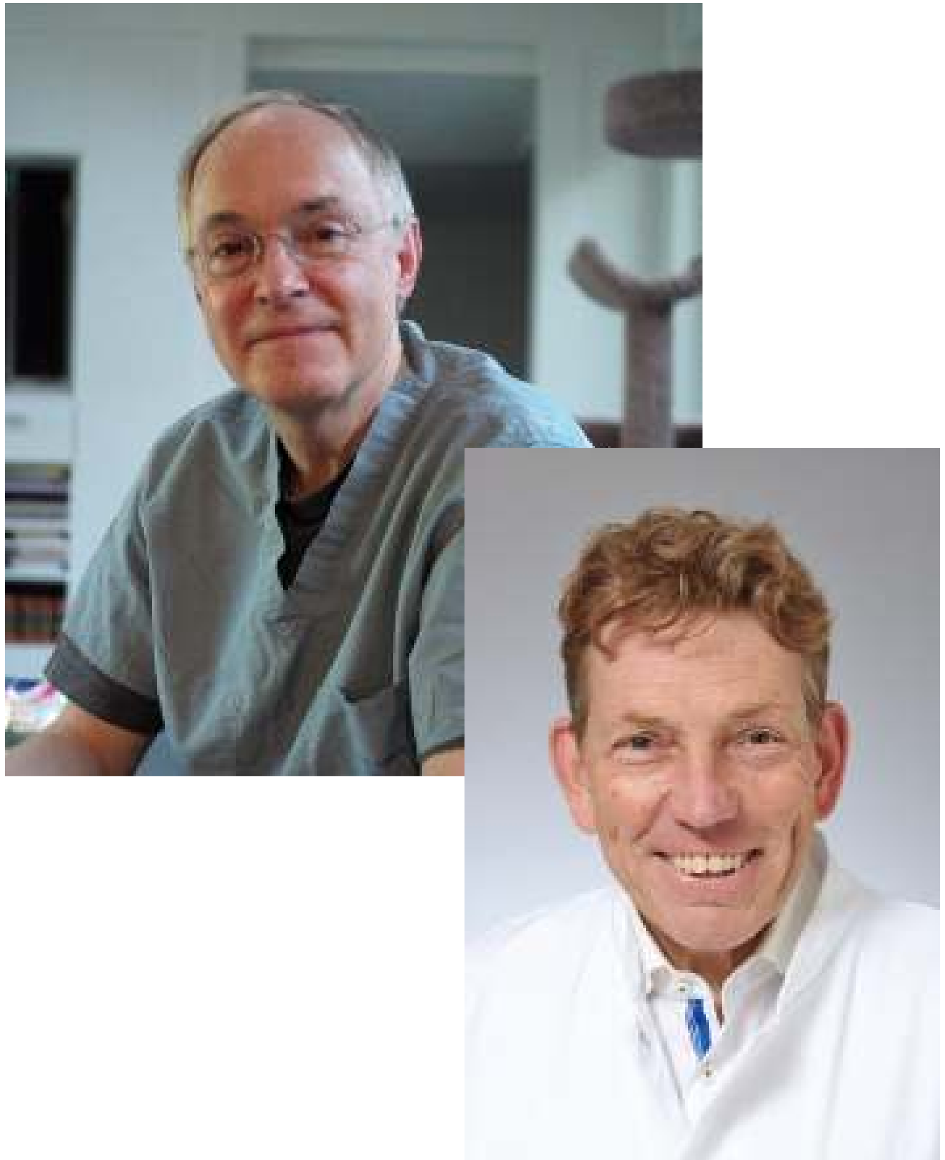
Standards for Analyzing Astigmatic Outcomes

Part I: Astigmatism Basics

Part II: Recommended Statistical Methods



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Acknowledgment

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In December 2020, The Journal of Cataract and Refractive Surgery (JCRS) formed a committee to reach and publish a consensus on clear and accurate astigmatism reporting guidelines to benefit JCRS authors and all researchers. The committee consisted of clinicians and researchers with expertise in this area. Following a series of virtual meetings, several of the committee members prepared the two manuscripts -- one on background and the second on standards for analyzing astigmatism. In addition to the authors of this paper, we want to acknowledge and thank the other members of the committee who made important contributions to the concepts incorporated in the written result of this project: Graham D. Barrett (MD, Australia), Laure Gobin (PhD, Belgium), and David Smadja (MD, Israel).

Standards for Analyzing Astigmatic Outcomes
Part I: Astigmatism Basics

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REVIEW/UPDATE

Standards for analyzing astigmatic outcomes: part I: astigmatism basics

Thomas Kohnen, MD, PhD, FEBO, Kristian Næser, MD, DSMC, Jack T. Holladay, MD, MSEE,
R. Doyle Stulting, MD, PhD, Li Wang, MD, PhD, Adi Abulafia, MD, PhD, Douglas D. Koch, MD

Astigmatism is the difference between the orthogonal principal planes of minimal and maximal powers of a toric surface, lens, or refraction. Corneal astigmatism is a common condition, and studies indicate that over 60% of individuals have more than 0.50 diopters of astigmatism. Corneal astigmatism is measured in various ways, and measurements from different devices are usually not interchangeable because of variations in technology and the corneal regions that are imaged. The integrity of the ocular surface is critically important for accurately measuring corneal astigmatism. Optimizing the ocular surface before cataract surgery can significantly improve the accuracy of preoperative astigmatism measurements and refractive outcomes. It is advisable to obtain at least 2 or preferably 3 measurements when measuring corneal astigmatism. When a discrepancy in astigmatism meridian and magnitude occurs between the measurements, it is advisable to settle or at least minimize this discrepancy by repeating the measurements after optimizing the ocular surface. Posterior corneal astigmatism is an important component of total corneal astigmatism. Lens tilt can also induce visually significant refractive astigmatism and ideally should be accounted for in toric intraocular lens planning.

J Cataract Refract Surg 2025; ■:1–7 Copyright © 2025 Published by Wolters Kluwer on behalf of ASCRS and ESCRS

Astigmatism analysis can be a complex, daunting, and sometimes contentious endeavor because of the complex nature of the topic, the variety of approaches available, and the shifting terminology. Over the past 3 decades, a variety of analytical methods have been proposed for predicting the residual refractive astigmatism after cataract and refractive surgery with the dual goals of guiding surgeons to provide optimal correction of astigmatism and enabling researchers to analyze and present outcomes of procedures that alter astigmatism. Although many of the new developments are helpful, the lack of general consensus on terminology and approach make it increasingly difficult to effectively compare and evaluate research in the area of astigmatism.

To bring clarity to the topic of astigmatism analysis for all current and future researchers, the *Journal of Cataract & Refractive Surgery* formed a working group to (1) establish astigmatic reporting guidelines based on sound optical principles and (2) provide new astigmatism calculation tools that simplify the process and allow researchers to reliably calculate accurate and reproducible results.

DEFINING ASTIGMATISM

In a *spherical* (*stigmatic* or *point-like*) optical system, a point in the object space is focused as a point image. An object located in the far point is focused on the retina. Objects from any other positions are defocused.[1]

In a *regular astigmatic* optical system, an object point is focused as 2 mutually perpendicular line segments delineating the Sturm interval.[1] Stated another way, astigmatism is the difference between the orthogonal principal planes of minimal and maximal powers of a toric surface, lens, or refraction. The curvature difference can be transformed to dioptric power using the radii of curvature and refractive indices of the refractive surface and surrounding media.[2] The optical effects of ocular astigmatism are blurring at all fixation distances because of a lack of point focus and, when corrected with cylindrical lenses, causes distortion in various meridians because of unequal magnification of the retinal image. Sphere and regular astigmatism are lower-order aberrations, correctable with spectacles or contact lenses. However, the optical quality of the human cornea is inferior to a diffraction-limited lens, with mean higher-order aberrations (also termed *irregular*

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From the Department of Ophthalmology, Goethe University, Frankfurt, Germany (Kohnen); Baylor College of Medicine, Houston, Texas (Holladay, Wang, Koch); Department of Ophthalmology, Randers Regional Hospital, Randers, Denmark (Næser); Woolfson Eye Institute, Atlanta, Georgia (Stulting); Department of Ophthalmology, Shaare Zedek Medical Center, Jerusalem, Israel (Abulafia).

Supported in part by SRB Charitable Corp., Fort Worth, Texas, the Sid W. Richardson Foundation, Fort Worth, Texas, and an unrestricted grant from Research to Prevent Blindness, New York, New York (Wang, Koch).

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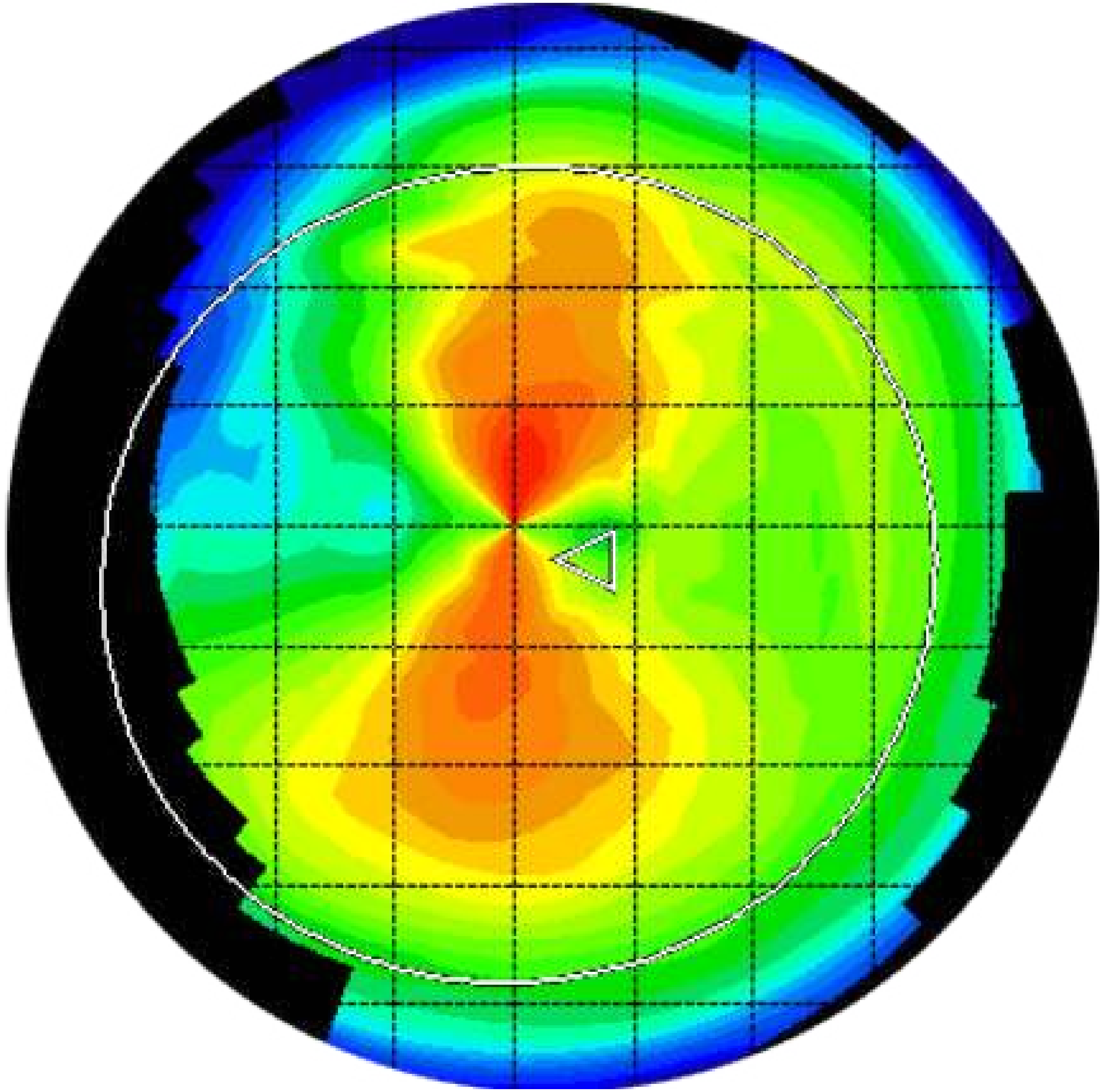
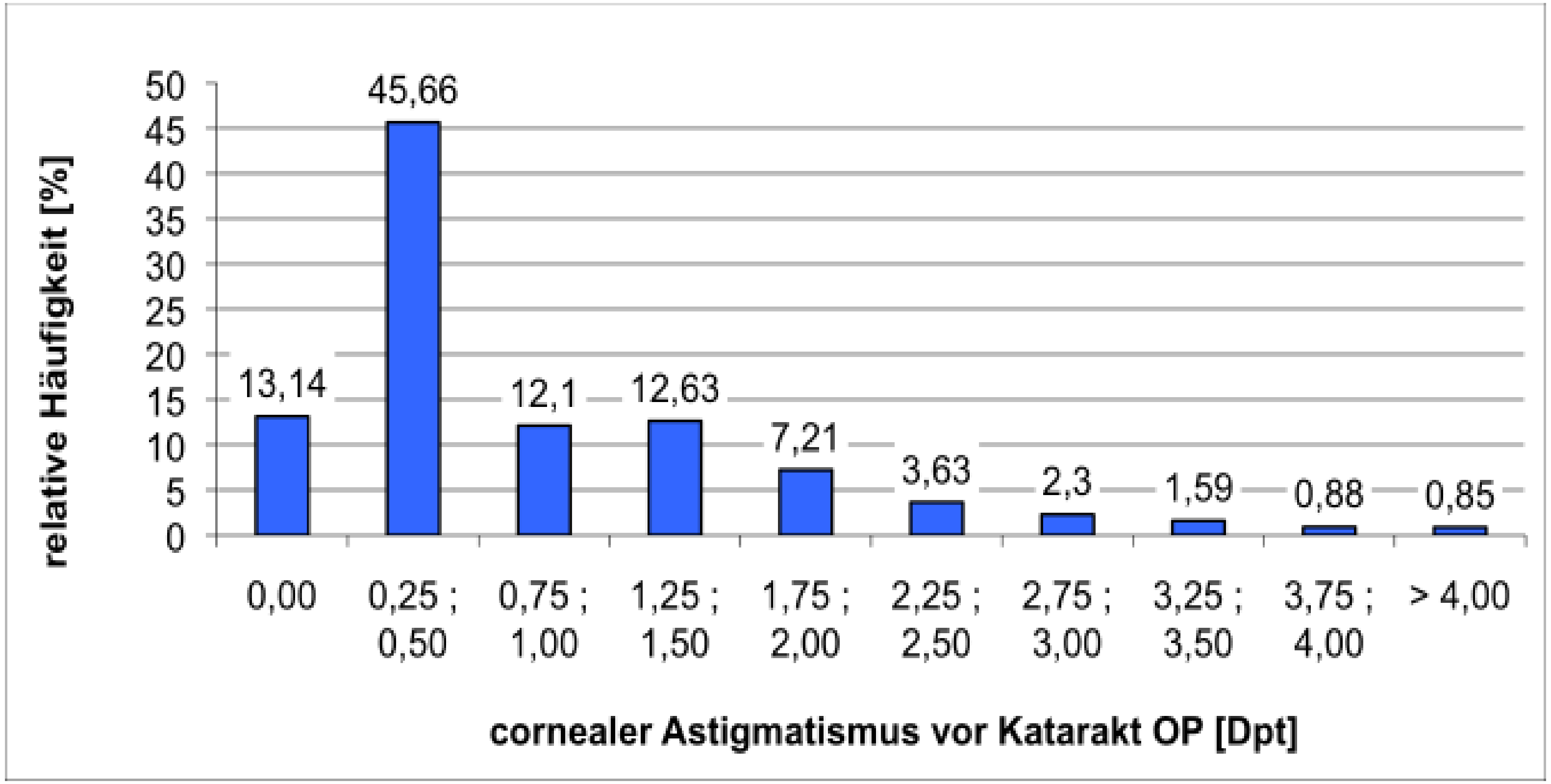
0886-3350/$ - see frontmatter

Astigmatism



Corneal astigmatism: frequency

Prevalence of corneal astigmatism before cataract surgery



58% ≤ 0,5D; 70% ≤ 1D

high astigmatism (>3D) rare!

Ferrer-Blasco T, Montes-Mico R, Peixoto-de-Matos SC, Gonzalez-Meijome JM, Cervino A. J Cataract Refract Surg 2009;35:70-5

Corneal astigmatism: measurements

Kerat

CT

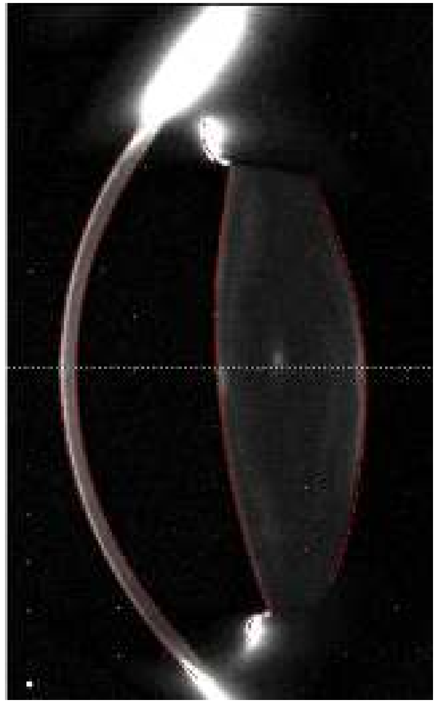
Important for measurements:

- Measure 2 or 3 times to confirm results
- Prior ocular surface optimization (artificial tears)
- Measure anterior and posterior astigmatism if possible

Kohnen T et al. Standards for analyzing astigmatic outcomes. Part I: Astigmatism basics. J Cataract Refract Surg (in press, 6/2025)

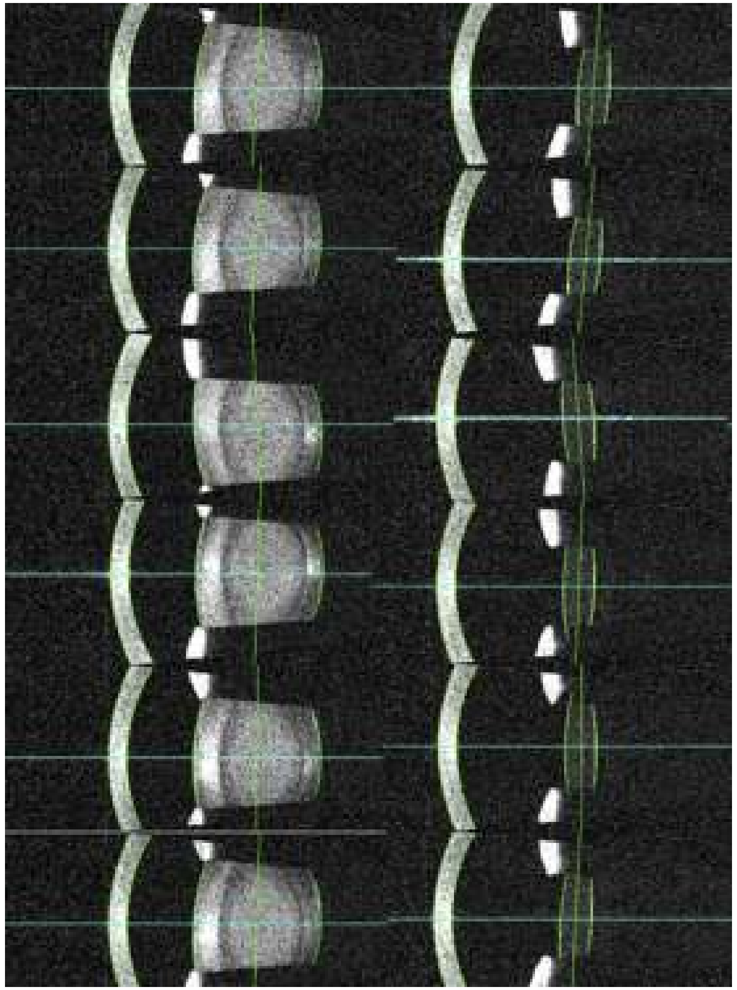
Studies on posterior corneal astigmatism

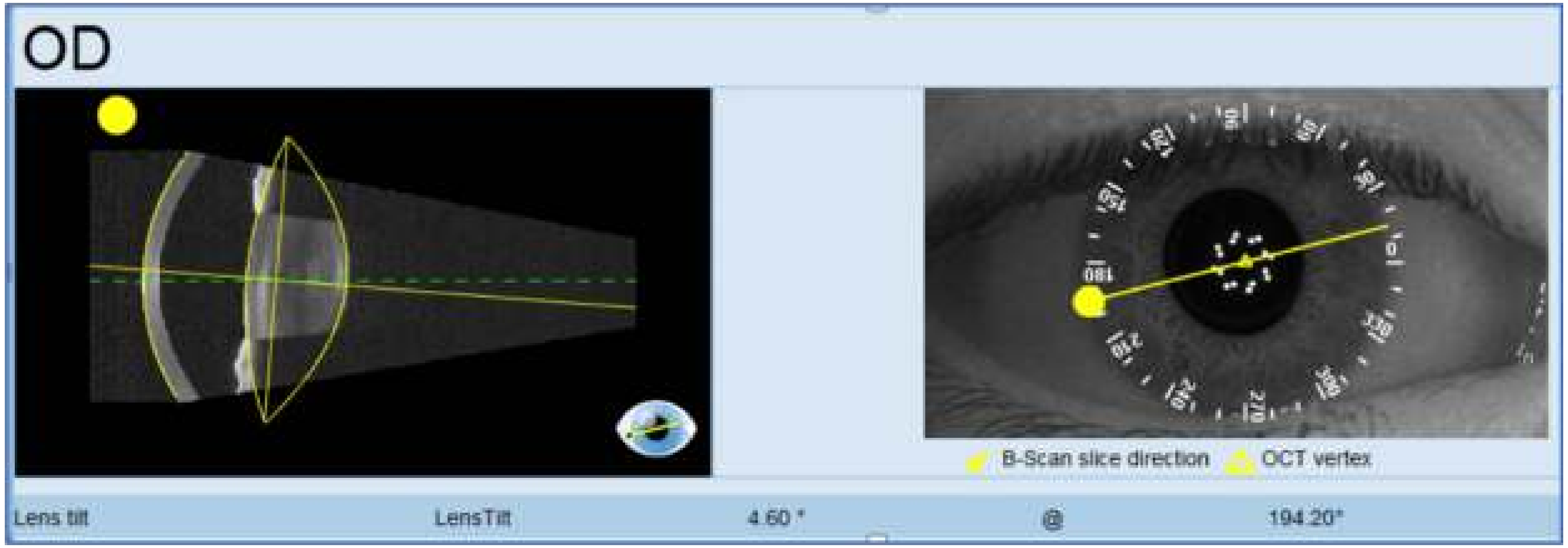
- The mean magnitude of CApost was appr. −**0.3** D
    - Ho et al. (2009): -0.33 D (0.00–0.94)
      n = 493, Scheimpflug imaging (Oculus Pentacam)
    - Koch et al. (2012): -0.30 D (0.01–1.10):
      n = 715, Scheimpflug imaging (Ziemer Galilei DAS)
    - Tonn et al. (2014): -0.33 D ± 0.18
      n = 3818, Scheimpflug imaging (Oculus Pentacam)



- Incoming parallel rays are refracted through the anterior and posterior corneal surface *(in accordance with Snell's law)*
    - with real refraction index numbers (1 for air, 1.376 for cornea, 1.336 for aqueous)
- refracted rays, instead of parallel rays, reach the posterior corneal surface

Lens tilt as an influence on astigmatism





OD

B-Scan slice direction
OCT vertex

Lens tilt	LensTilt	4.60 °	@	194.20°

Kohnen T et al. Standards for analyzing astigmatic outcomes. Part I: Astigmatism basics. J Cataract Refract Surg (in press, 6/2025)

What is known

REVIEW/UPDATE

Standards for analyzing astigmatic outcomes: part I: astigmatism basics

Thomas Kohnen, MD, PhD, FEBO, Kristian Naeser, MD, DSMC, Jack T. Holladay, MD, MSEE, R. Doyle Stulting, MD, PhD, Li Wang, MD, PhD, Adi Abulafia, MD, PhD, Douglas D. Koch, MD

- Astigmatism is the difference between the two main orthogonal planes of a toric surface or lens

- Over 60% of people have more than 0.5 D of corneal astigmatism

- With more cataract and elective lens surgeries, predicting residual astigmatism has become crucial

- Despite many measurement methods, inconsistent terminology and approaches hinder comparisons

REVIEW/UPDATE

Standards for analyzing astigmatic outcomes: part I: astigmatism basics

Thomas Kohnen, MD, PhD, FEBO, Kristian Naeser, MD, DSMC, Jack T. Holladay, MD, MSEE, R. Doyle Stulting, MD, PhD, Li Wang, MD, PhD, Adi Abulafia, MD, PhD, Douglas D. Koch, MD

What this paper adds

- We suggest a consistent use of terminology and provide clear explanations and definitions for measuring astigmatism
- The integrity of the ocular surface is critically important for accurately measuring corneal astigmatism
- We provide clear and accurate astigmatism reporting guidelines based on sound optical principles

Standards for Analyzing Astigmatic Outcomes

Part II: Recommended Statistical Methods

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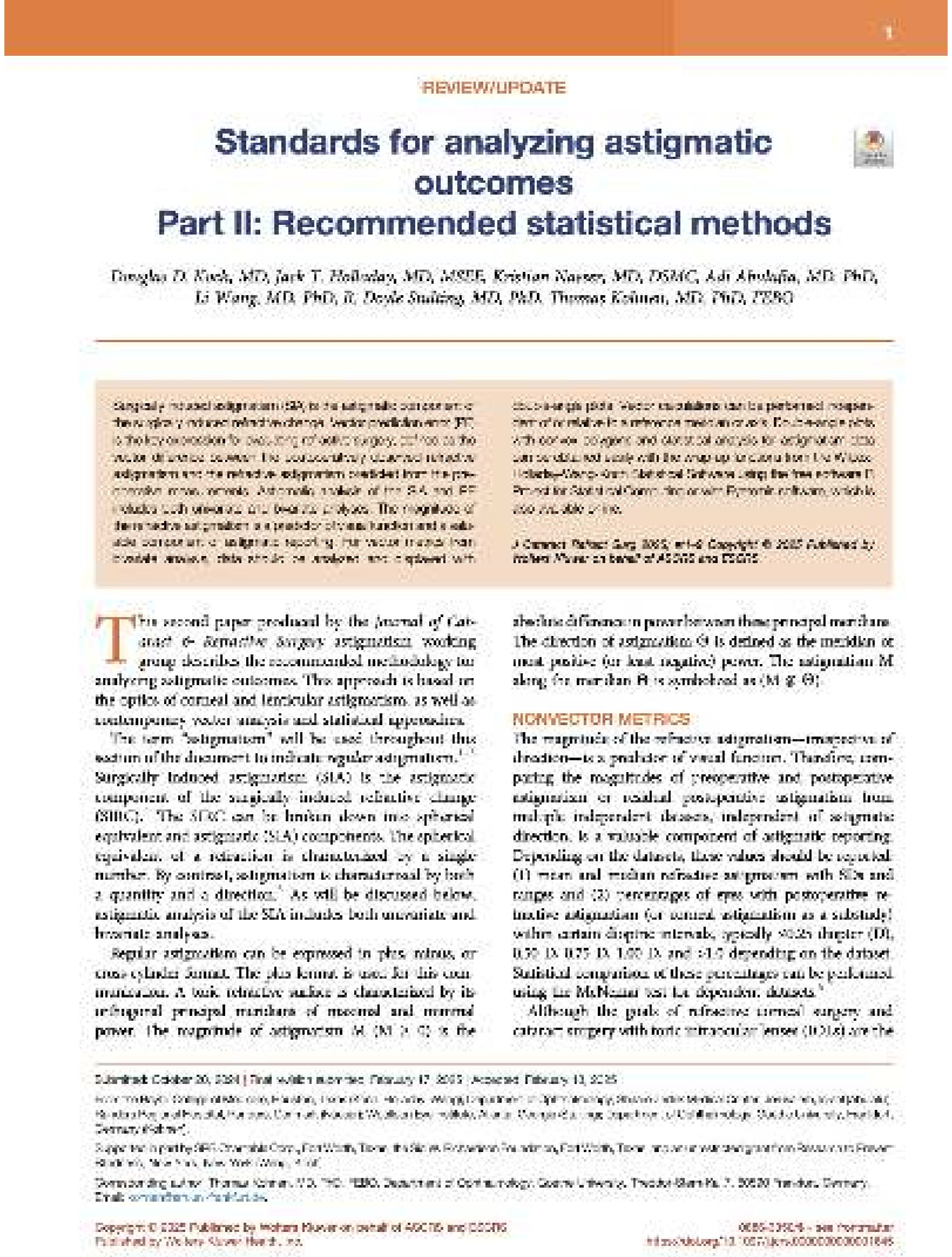


REVIEW/UPDATE

Standards for analyzing astigmatic outcomes
Part II: Recommended statistical methods

Douglas D. Koch, MD, Jack T. Holladay, MD, MSEE, Kristian Naeser, MD, DSMC, Adi Abulafia, MD, PhD, Li Wang, MD, PhD, R. Doyle Stulting, MD, PhD, Thomas Kohnen, MD, PhD, FEBO

NONVECTOR METRICS

Analyzing astigmatic outcomes

- 1. What do we want to know?
  - How well does the patient see…uncorrected vision
    - But it is affected by spherical error so not specific enough
  - Actual amounts of residual astigmatism: ***scalar values***
  - How accurate are the outcomes compared to the predicted: ***vector prediction error***

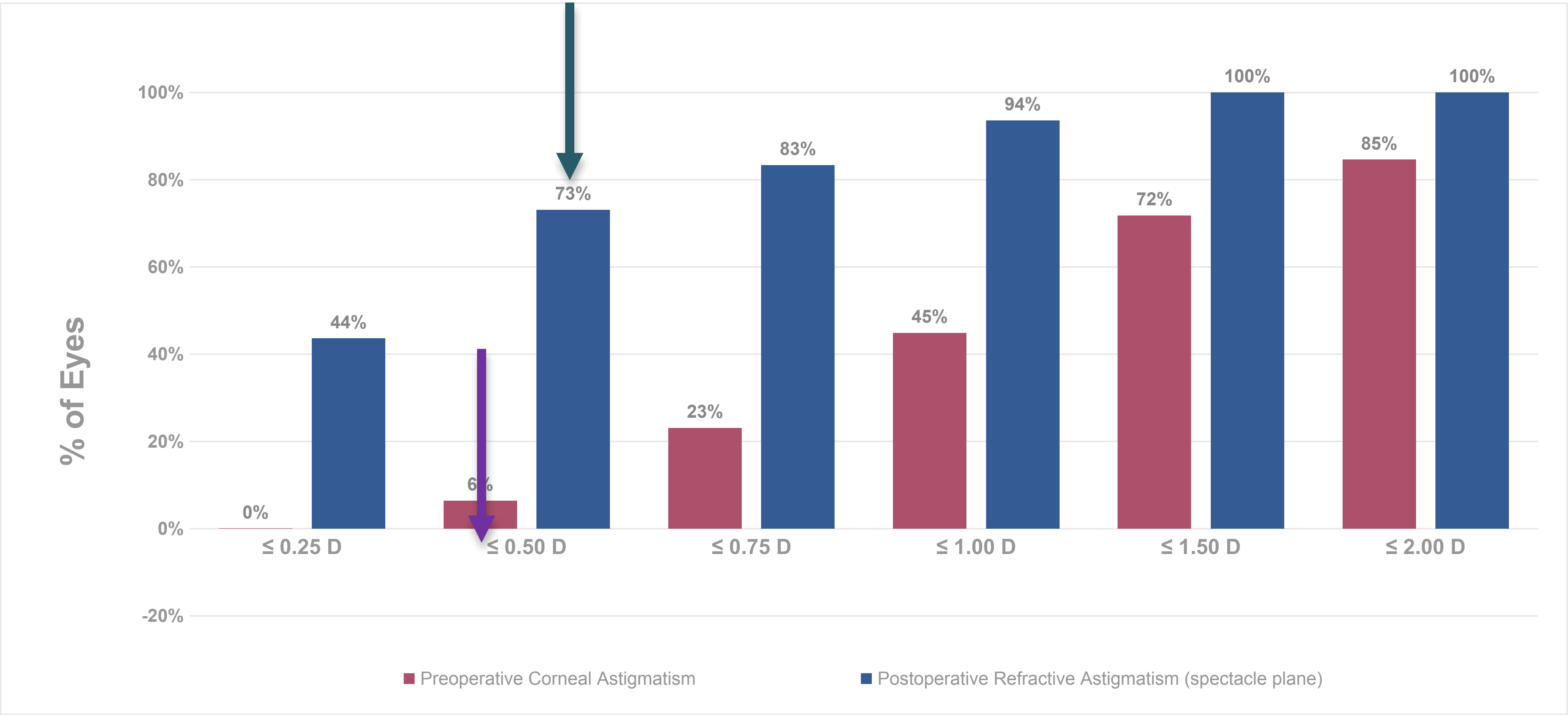
Koch DD, et al. Standards for analyzing astigmatic outcomes. Part II: Recommended statistical methods. J Cataract Refract Surg (in press, 6/2025)

Analyzing astigmatic outcomes

- 2. What do we want to know?
  - Refractive astigmatism: ***scalar values***
    - % of eyes with ≤ 0.25, 0.5, 0.75 D etc.
    - Especially useful for procedures that target 0 astigmatism, eg, LASIK

Koch DD, et al. Standards for analyzing astigmatic outcomes. Part II: Recommended statistical methods. J Cataract Refract Surg (in press, 6/2025)

Figure 1: Cumulative histogram of dioptric bins



Abulafia A et al. J Cataract Refract Surg 2018; 44:1169-1174

Analyzing toric IOL astigmatic outcomes

- How accurate is the formula for hitting the predicted targets?
  - More complicated for toric IOLs
  - The target is not zero due to 0.75 D IOL steps at IOL plane

Koch DD, et al. Standards for analyzing astigmatic outcomes. Part II: Recommended statistical methods. J Cataract Refract Surg (in press, 6/2025)

Analyzing astigmatism outcomes

- Complicated!
- Astigmatism has 2 variables:
  - Power or magnitude
  - Meridian or axis
  - You don’t get reliable information by analyzing either in isolation
  - Bivariate analysis is mandatory

Koch DD, et al. Standards for analyzing astigmatic outcomes. Part II: Recommended statistical methods. J Cataract Refract Surg (in press, 6/2025)

What variables should we analyze?

3. We want to compare the magnitude *and* angle of the postop refractive astigmatism to predict:

- ***Vector prediction error***
- Vector difference between ”Actual” and “Predicted”
- This describes the true accuracy of the formula/procedure
- Critical data in order to refine formula and procedures to improve outcomes

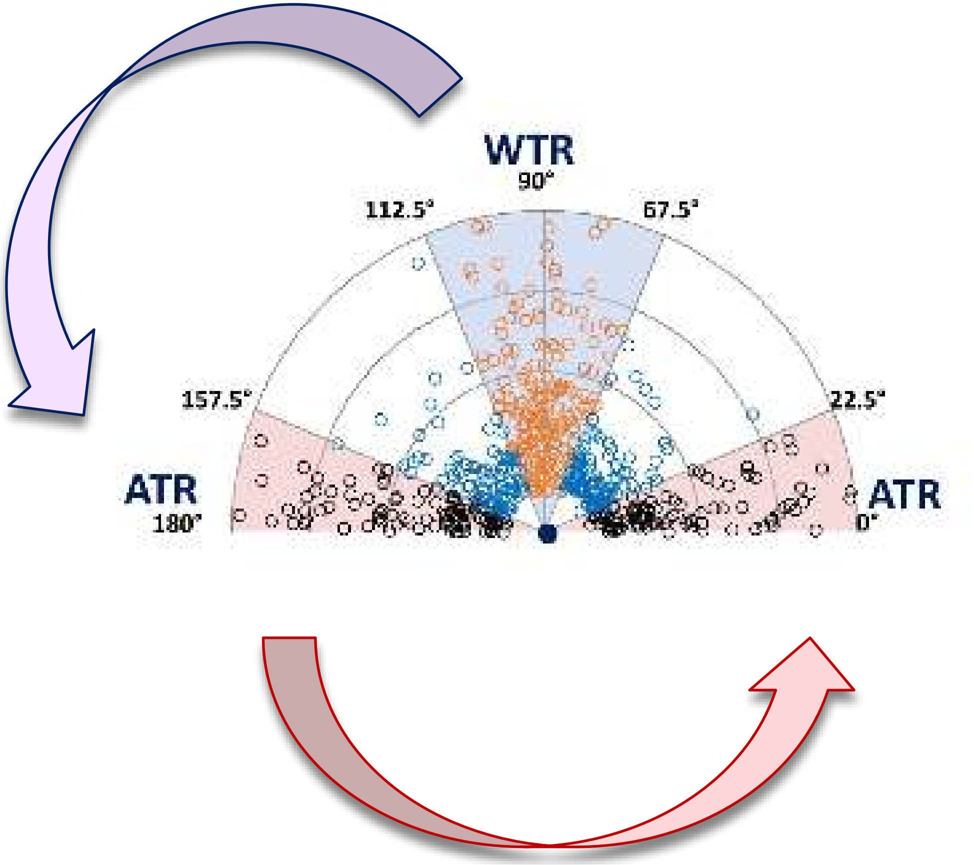
Koch DD, et al. Standards for analyzing astigmatic outcomes. Part II: Recommended statistical methods. J Cataract Refract Surg (in press, 6/2025)

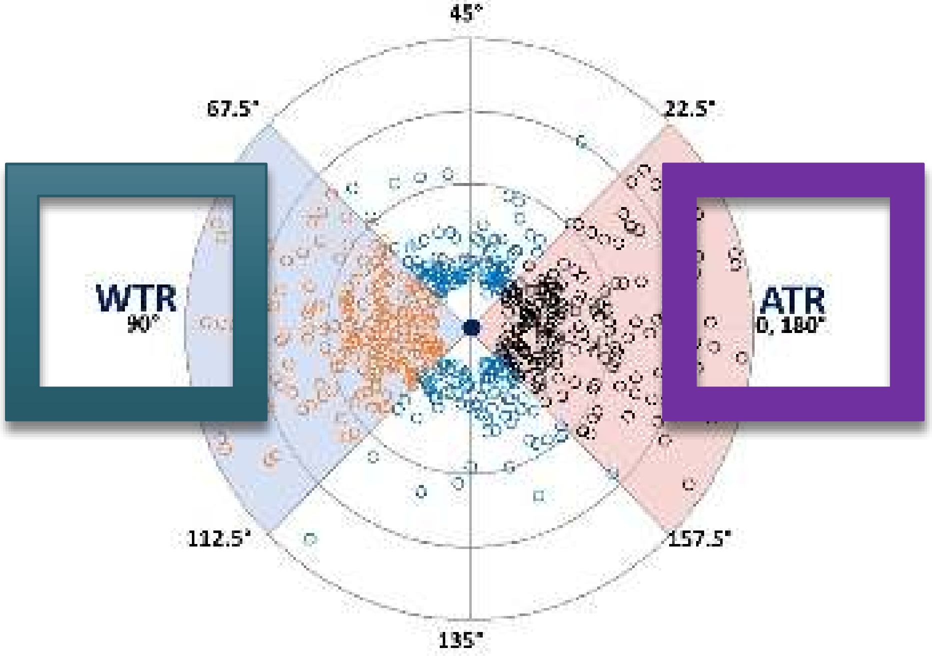
To analyze astigmatism

- Break it down into cartesian values:
  - $x = C*\cos(2*\alpha)$
  - $y = C*\sin(2*\alpha)$
- Perform calculations on x and y separately
- Reassemble x and y into the astigmatic value in conventional notation

Koch DD, et al. Standards for analyzing astigmatic outcomes. Part II: Recommended statistical methods. J Cataract Refract Surg (in press, 6/2025)

Single-angle vs. double-angle plots

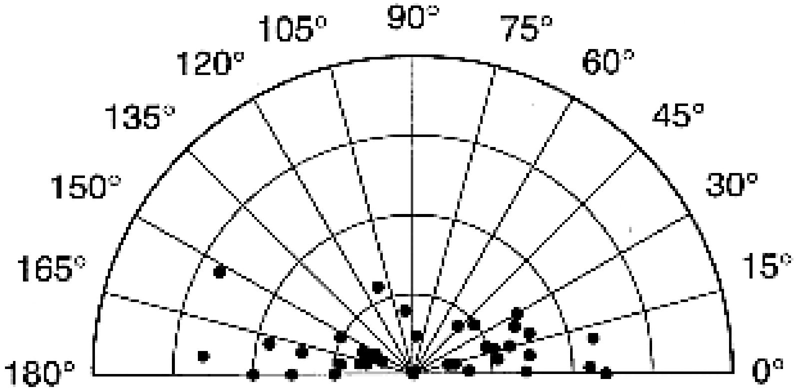




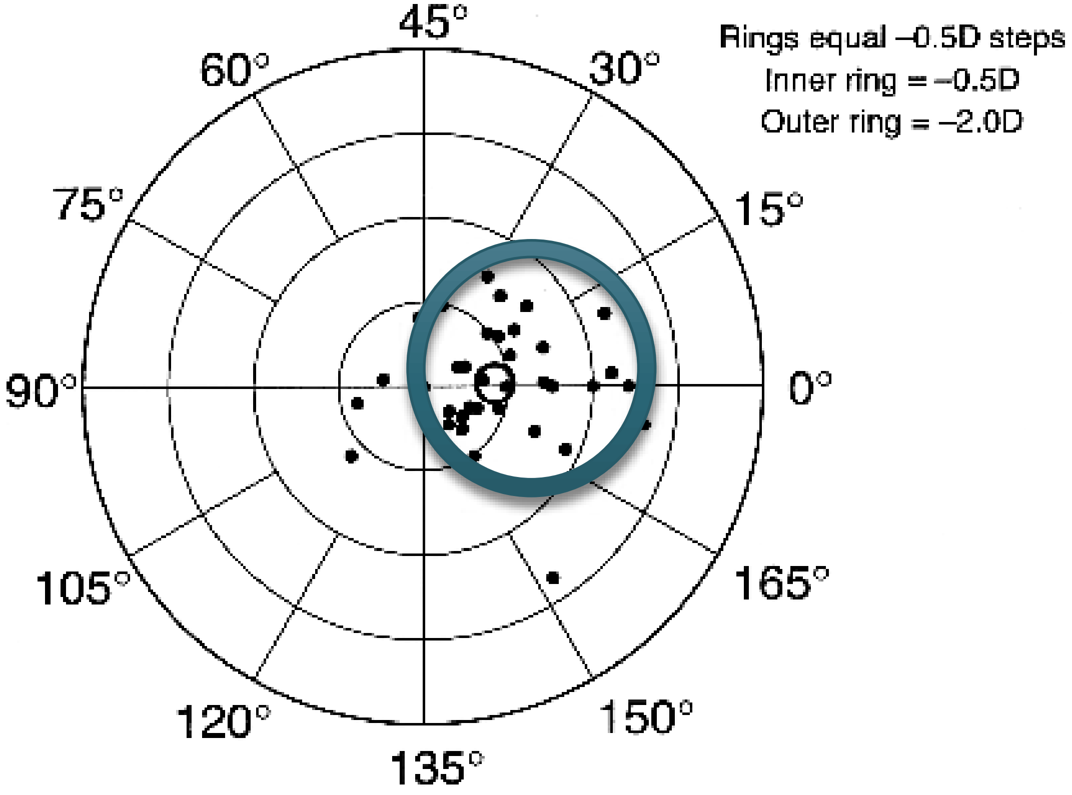
Abulafia A, Koch DD, Holladay JT, Wang L, Hill W. J Cataract Refract Surg 2018; 44:1169-1174

Same exact data points

Single angle plot



Double angle plot



Each ring = 0.5 D

- Looks like phoropter
- But hard to really know what the data show

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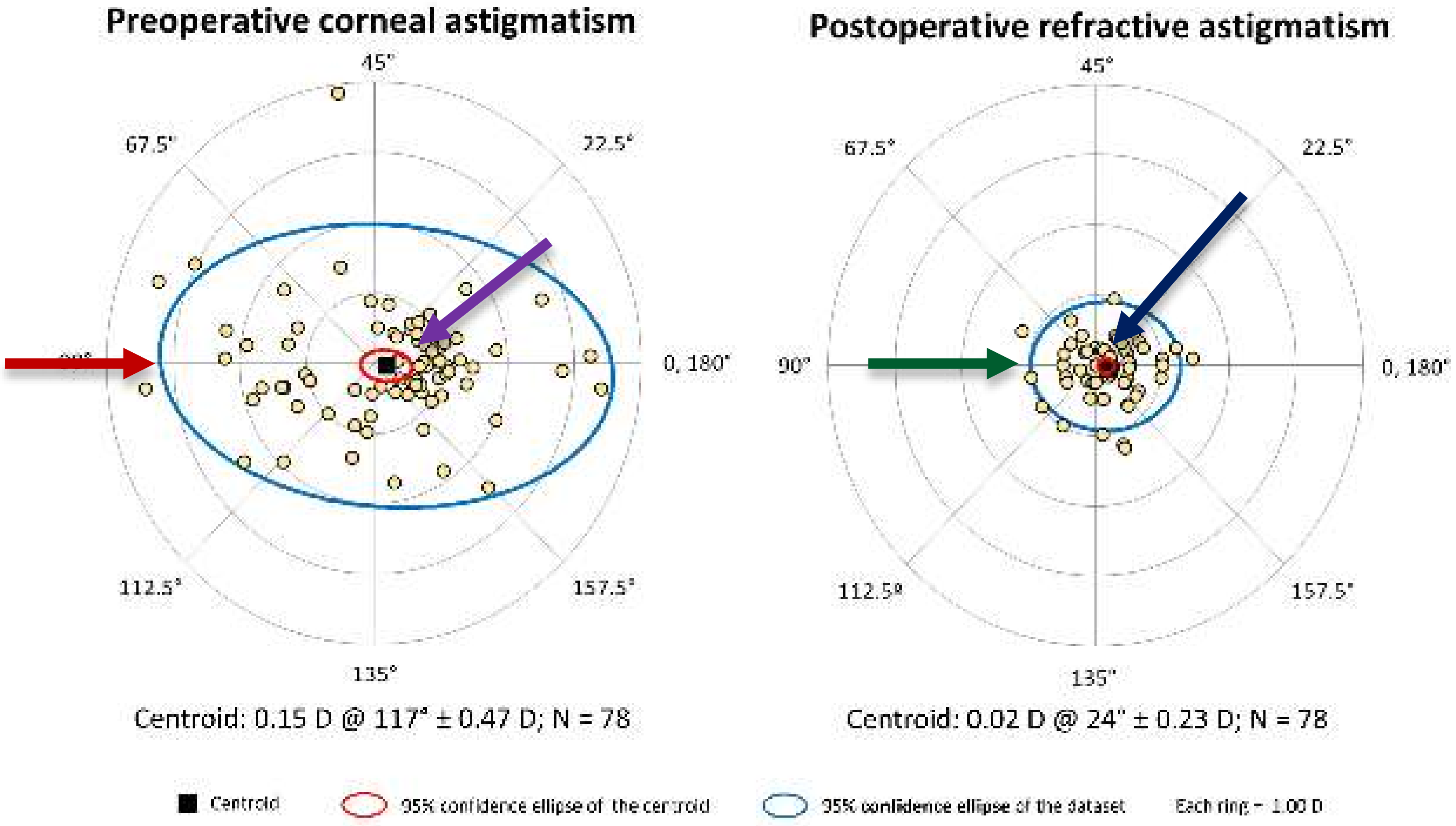
Example of pre- and postop data



Preoperative corneal astigmatism

Centroid: 0.15 D @ 117° ± 0.47 D; N = 78

Postoperative refractive astigmatism

Centroid: 0.02 D @ 24° ± 0.23 D; N = 78

■ Centroid
○ 95% confidence ellipse of the centroid
○ 95% confidence ellipse of the dataset
Each ring = 1.00 D

Abulafia A, Koch DD, Holladay JT, Wang L, Hill W. J Cataract Refract Surg. 2018; 44:1169-1174

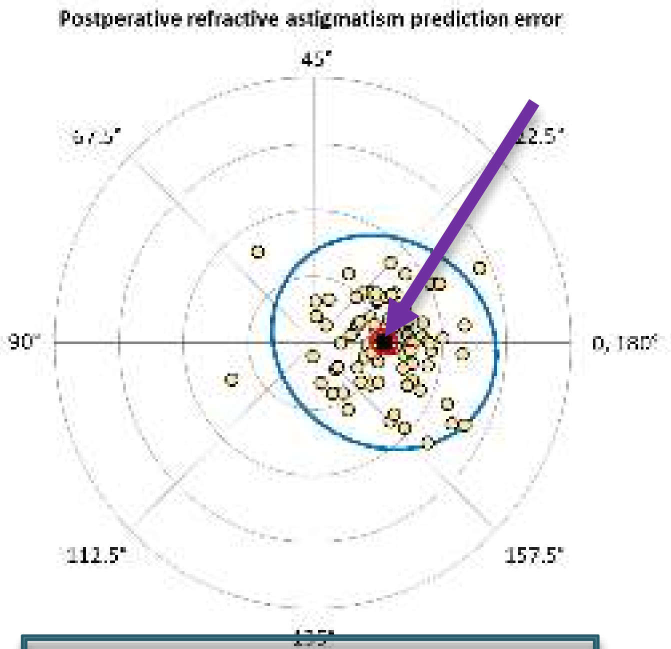
What about statistical analysis

- You can have a mean error—centroid--of zero and a huge spread (large confidence ellipse)
- You can have a small spread but a large mean error
- Only the ***vector prediction error*** takes both into account

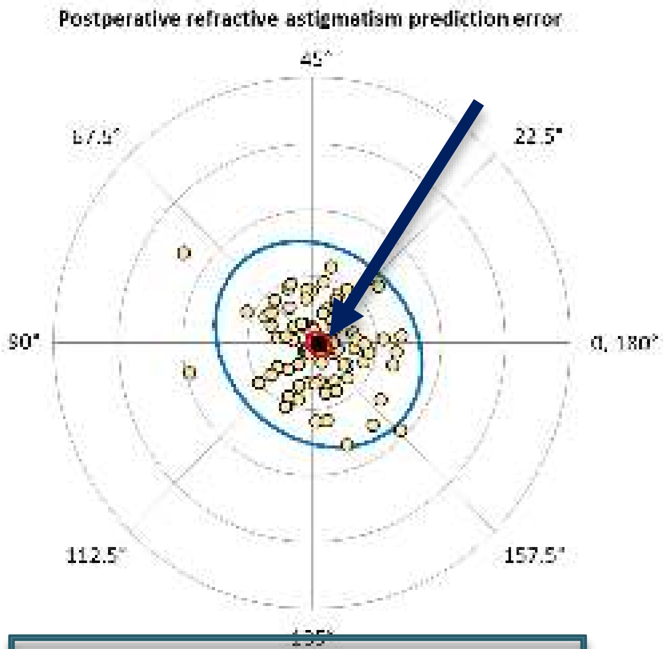
Koch DD, et al. Standards for analyzing astigmatic outcomes. Part II: Recommended statistical methods. J Cataract Refract Surg (in press, 6/2025)

Example comparing formulas

Toric IOL calculation based on anterior Ks



Centroid: 0.55 D @ 180° ± 0.47 D; N = 78



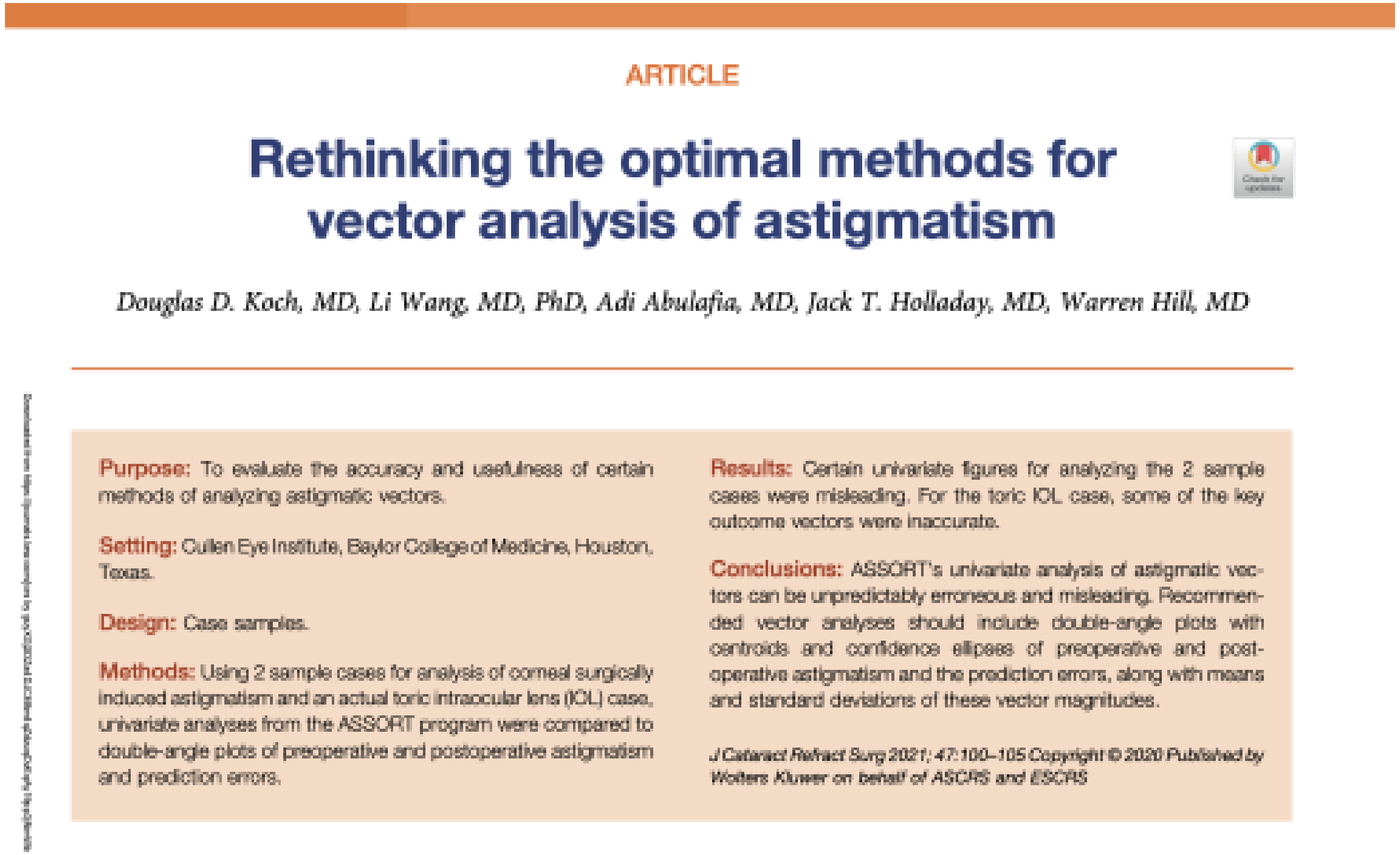
Centroid: 0.05 D @ 174° ± 0.44 D; N = 78

Toric IOL calculation with Abulafia-Koch

■ Centroid ⬭ 95% confidence ellipse of the centroid ⬭ 95% confidence ellipse of the dataset Each ring = 0.50 D

Why can’t we analyze power & angle separately?

- Because it gives incorrect answers



ARTICLE

Rethinking the optimal methods for vector analysis of astigmatism

Douglas D. Koch, MD, Li Wang, MD, PhD, Adi Abulafia, MD, Jack T. Holladay, MD, Warren Hill, MD

Purpose: To evaluate the accuracy and usefulness of certain methods of analyzing astigmatic vectors.

Setting: Cullen Eye Institute, Baylor College of Medicine, Houston, Texas.

Design: Case samples.

Methods: Using 2 sample cases for analysis of corneal surgically induced astigmatism and an actual toric intraocular lens (IOL) case, univariate analyses from the ASSORT program were compared to double-angle plots of preoperative and postoperative astigmatism and prediction errors.

Results: Certain univariate figures for analyzing the 2 sample cases were misleading. For the toric IOL case, some of the key outcome vectors were inaccurate.

Conclusions: ASSORT's univariate analysis of astigmatic vectors can be unpredictably erroneous and misleading. Recommended vector analyses should include double-angle plots with centroids and confidence ellipses of preoperative and postoperative astigmatism and the prediction errors, along with means and standard deviations of these vector magnitudes.

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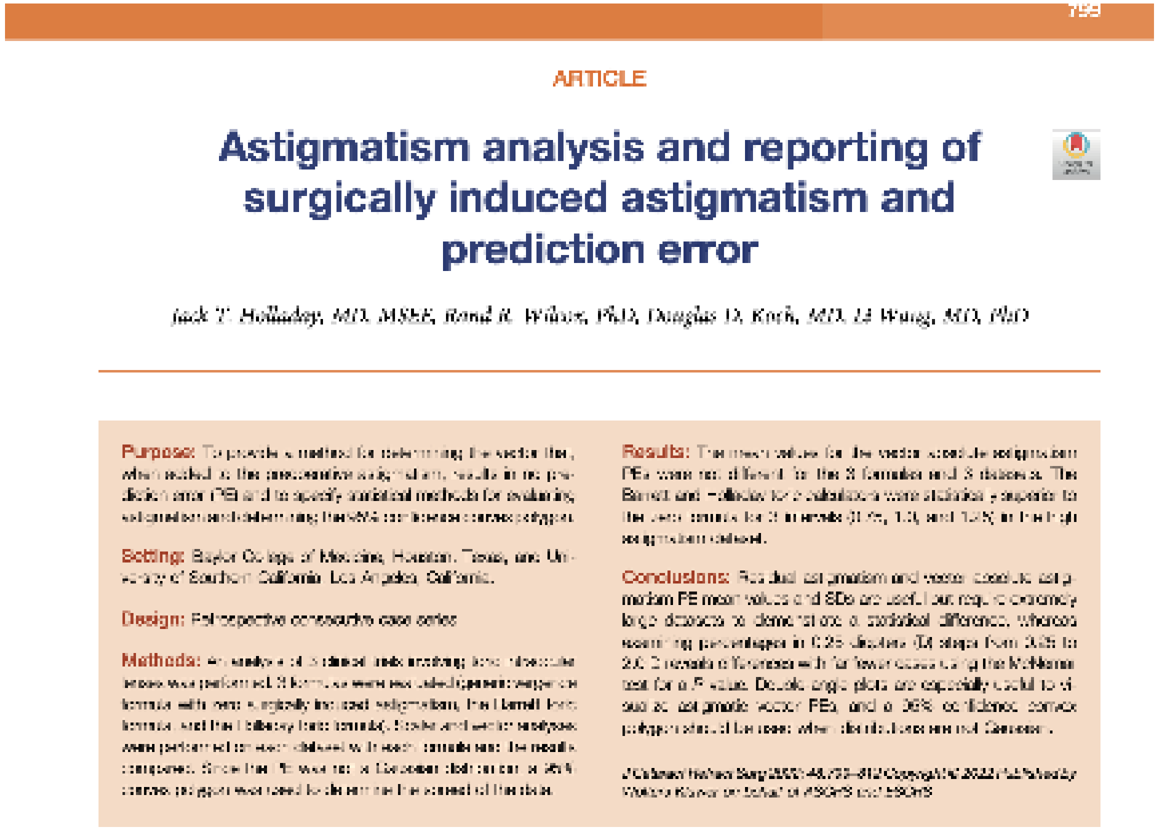
Statistics: new insights in bivariate analysis

1

- Data are not normally distributed
- Requires different stats than have been used in the past
- Holladay et al: R Project for Computing (Rand Wilcox)
- Instead of ellipse: convex polygon to display the data



799

ARTICLE

Astigmatism analysis and reporting of surgically induced astigmatism and prediction error

Jack T. Holladay, MD, MSEE, Rand R. Wilcox, PhD, Douglas D. Koch, MD, Li Wang, MD, PhD

Setting: Baylor College of Medicine, Houston, Texas, and University of Southern California, Los Angeles, California.

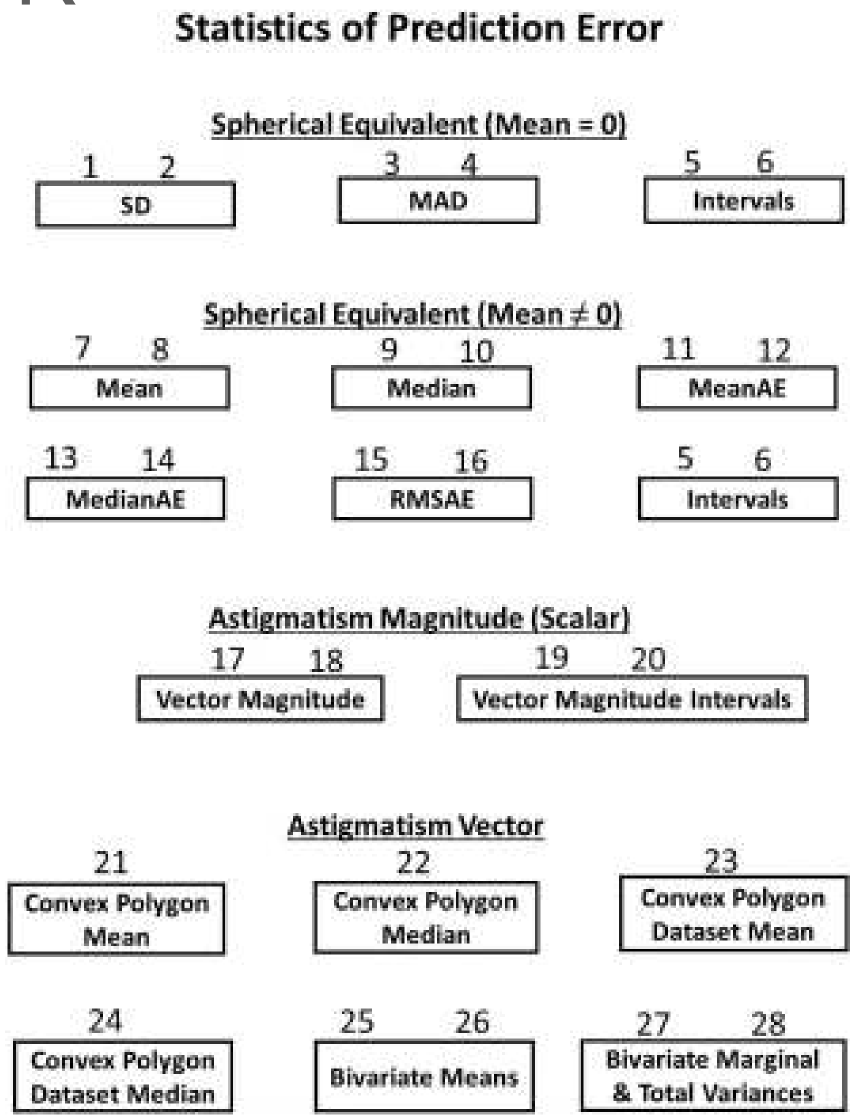
Design: Retrospective consecutive case series.

Holladay JT, Wilcox RR, Koch DD, Wang L.J Cataract Refract Surg 2022; 48:799–812

Wrap-up function in R

1

- Simplify the use of 28 functions
- Perform analysis in a batch mode
- Only need to upload data once for all analyses:
  - IOL power calculation
  - Astigmatism analysis



Statistics of Prediction Error

Spherical Equivalent (Mean = 0)

1 2 SD

3 4 MAD

5 6 Intervals

Spherical Equivalent (Mean ≠ 0)

7 8 Mean

9 10 Median

11 12 MeanAE

13 14 MedianAE

15 16 RMSAE

5 6 Intervals

Astigmatism Magnitude (Scalar)

17 18 Vector Magnitude

19 20 Vector Magnitude Intervals

Astigmatism Vector

21 Convex Polygon Mean

22 Convex Polygon Median

23 Convex Polygon Dataset Mean

24 Convex Polygon Dataset Median

25 26 Bivariate Means

27 28 Bivariate Marginal & Total Variances

*Wang L, Holladay J, Wilcox RR, Koch DD. JCRS 2023;49:890-891

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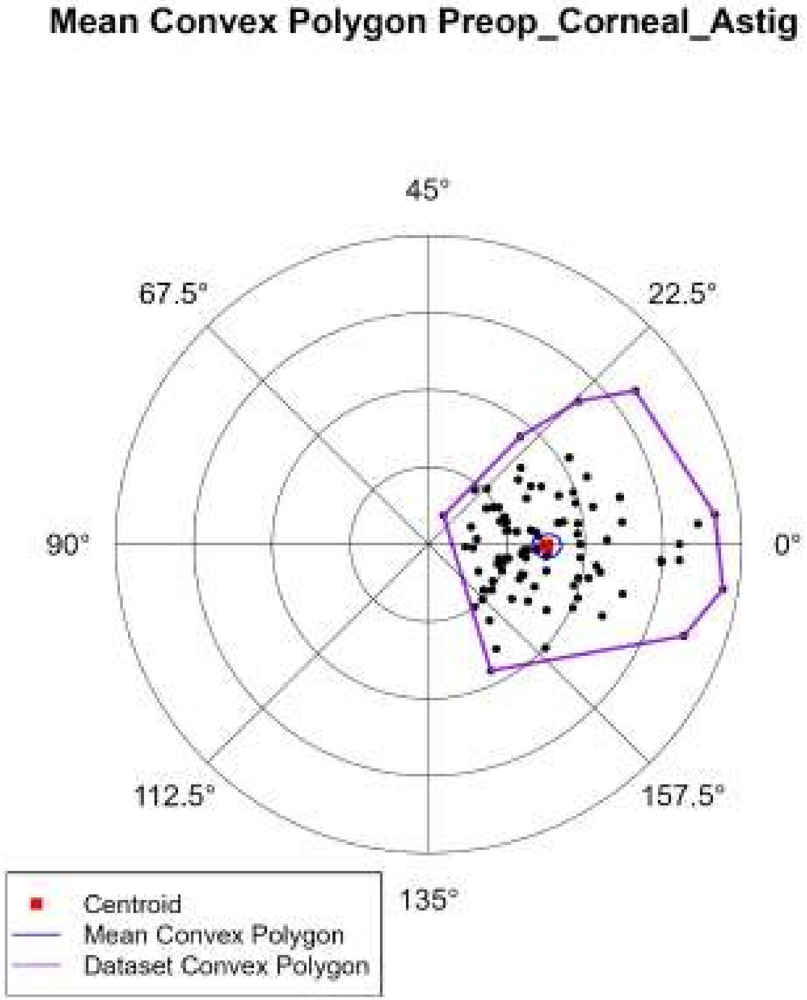
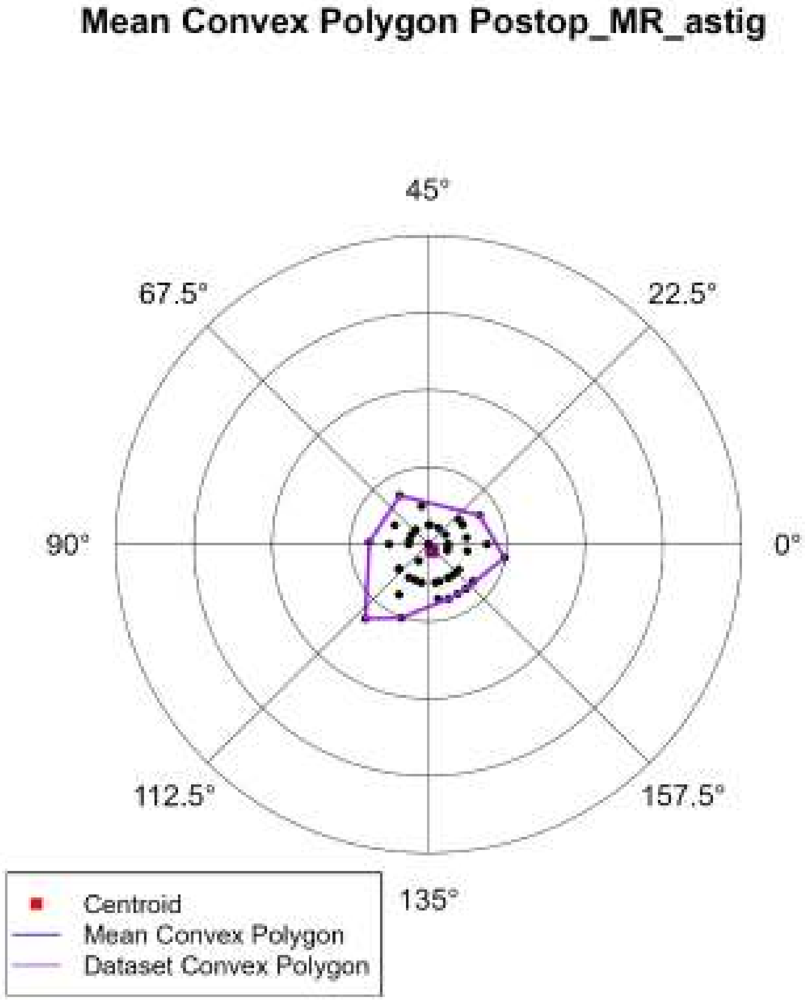

Mean Convex Polygon Preop_Corneal_Astig


Mean Convex Polygon Postop_MR_astig

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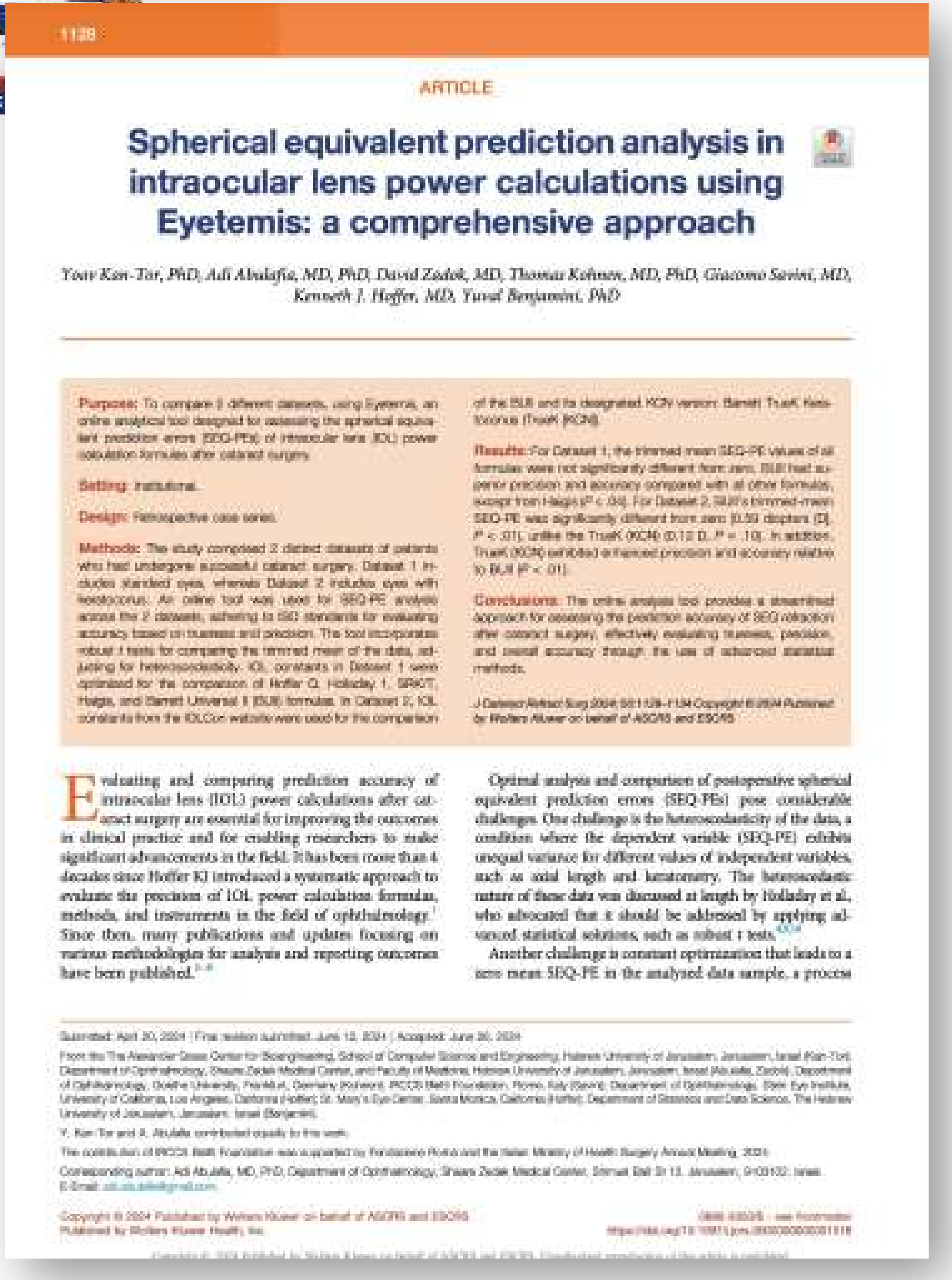

ARTICLE

Spherical equivalent prediction analysis in intraocular lens power calculations using Eyetemis: a comprehensive approach

Yoav Kan-Tor, PhD, Adi Abulafia, MD, PhD, David Zadok, MD, Thomas Kohnen, MD, PhD, Giacomo Savini, MD, Kenneth J. Hoffer, MD, Yuval Benjamini, PhD

Purpose: To compare 2 different datasets, using Eyetemis, an online analytical tool designed for assessing the spherical equivalent prediction errors (SEQ-PEs) of intraocular lens (IOL) power calculation formulas after cataract surgery.

Setting: Institutional.

Design: Retrospective case series.

Methods: The study comprised 2 distinct datasets of patients who had undergone successful cataract surgery. Dataset 1 includes standard eyes, whereas Dataset 2 includes eyes with keratoconus. An online tool was used for SEQ-PE analysis across the 2 datasets, adhering to ISO standards for evaluating accuracy based on trueness and precision. The tool incorporates robust t tests for comparing the trimmed mean of the data, adjusting for heteroscedasticity. IOL constants in Dataset 1 were optimized for the comparison of Hoffer Q, Holladay 1, SRK/T, Haigis, and Barrett Universal II (BUII) formulas. In Dataset 2, IOL constants from the IOLCon website were used for the comparison of the BUII and its designated KCN version: Barrett TrueK Keratoconus (TrueK (KCN)).

Results: For Dataset 1, the trimmed mean SEQ-PE values of all formulas were not significantly different from zero. BUII had superior precision and accuracy compared with all other formulas, except from Haigis ($P < .04$). For Dataset 2, BUII's trimmed-mean SEQ-PE was significantly different from zero (0.59 diopters (D), $P < .01$), unlike the TrueK (KCN) (0.12 D, $P = .10$). In addition, TrueK (KCN) exhibited enhanced precision and accuracy relative to BUII ($P < .01$).

Conclusions: The online analysis tool provides a streamlined approach for assessing the prediction accuracy of SEQ refraction after cataract surgery, effectively evaluating trueness, precision, and overall accuracy through the use of advanced statistical methods.

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Evaluating and comparing prediction accuracy of intraocular lens (IOL) power calculations after cataract surgery are essential for improving the outcomes in clinical practice and for enabling researchers to make significant advancements in the field. It has been more than 4 decades since Hoffer KJ introduced a systematic approach to evaluate the precision of IOL power calculation formulas, methods, and instruments in the field of ophthalmology.[1] Since then, many publications and updates focusing on various methodologies for analysis and reporting outcomes have been published.[2–8]

Optimal analysis and comparison of postoperative spherical equivalent prediction errors (SEQ-PEs) pose considerable challenges. One challenge is the heteroscedasticity of the data, a condition where the dependent variable (SEQ-PE) exhibits unequal variance for different values of independent variables, such as axial length and keratometry. The heteroscedastic nature of these data was discussed at length by Holladay et al, who advocated that it should be addressed by applying advanced statistical solutions, such as robust t tests.[7,9,10]

Another challenge is constant optimization that leads to a zero mean SEQ-PE in the analyzed data sample, a process

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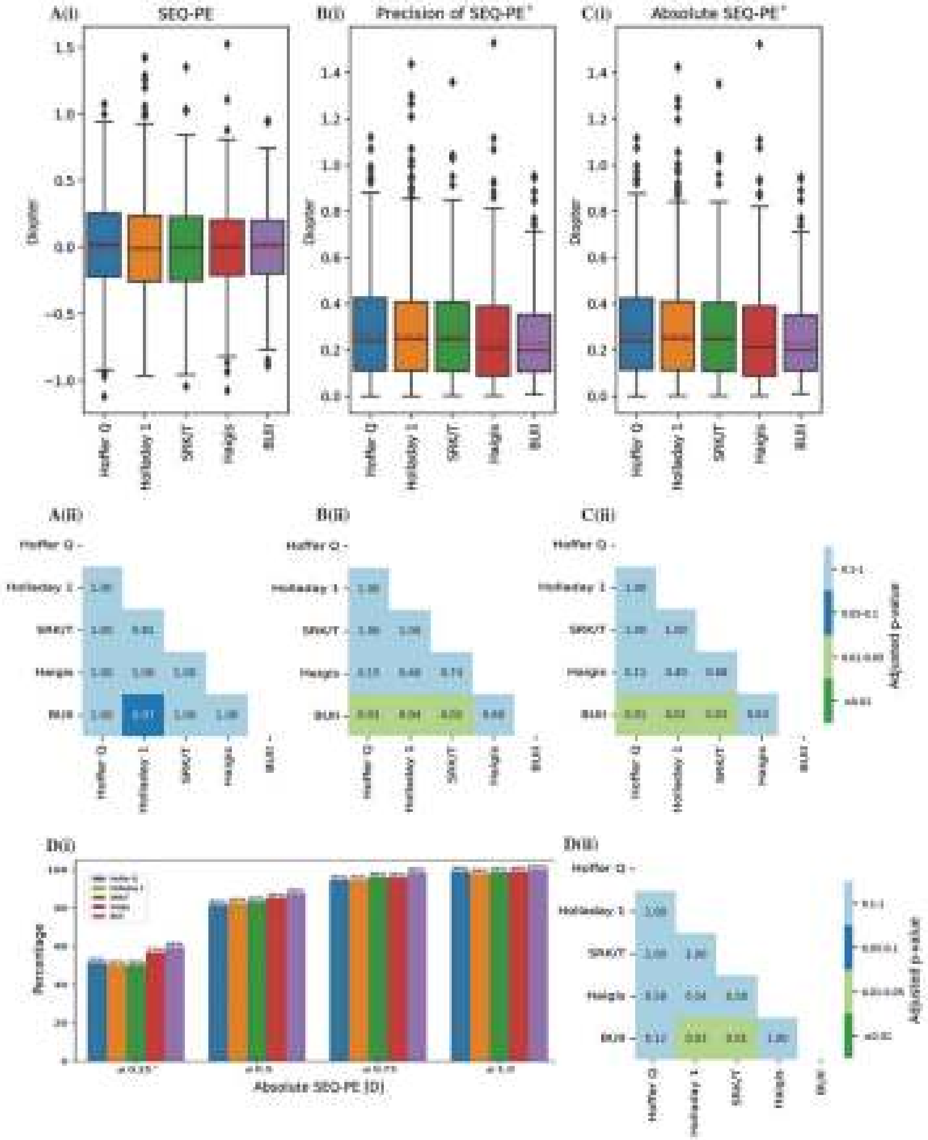

2

An online analysis tool for SEQ-PE & astigmatism assessment

- Provides a streamlined approach for evaluating SEQ-PE and astigmatism
- Analysis adheres to the ISO standards for Accuracy, encompassing both "trueness" and "precision"
- Utilizes robust t-tests (univariate and bivariate) to compare the trimmed-mean of data, accounting for heteroscedasticity
- Includes standard threshold tests to ensure comprehensive analysis

Summary: Analysis of astigmatic outcomes

- ***Scalar*** values for magnitude of astigmatism
- ***Vector*** prediction errors
  - Double-angle plots for display and further analysis
    - Centroids and convex polygons
  - Stats using R **1** or Eyetemis **2**

- JCRS committee submitted 2 position papers to establish these guidelines

What is known


REVIEW/UPDATE

Standards for analyzing astigmatic outcomes
Part II: Recommended statistical methods

Douglas D. Koch, MD, Jack T. Holladay, MD, MSEE, Kristian Naeser, MD, DSMC, Adi Abulafia, MD, PhD, Li Wang, MD, PhD, R. Doyle Stulting, MD, PhD, Thomas Kohnen, MD, PhD, FEBO

- Astigmatism analysis requires both scalar and vector outcomes
- Vector prediction error is key to assessing changes from corneal or lens procedures
- Vector analysis uses double-angle plots, doubling axes or meridians
- Astigmatic data often deviate from normal distribution and need non-Gaussian methods

What this paper adds

REVIEW/UPDATE

Standards for analyzing astigmatic outcomes
Part II: Recommended statistical methods

Douglas D. Koch, MD, Jack T. Holladay, MD, MSEE, Kristian Naeser, MD, DSMC, Adi Abulafia, MD, PhD, Li Wang, MD, PhD, R. Doyle Stulting, MD, PhD, Thomas Kohnen, MD, PhD, FEBO

- We present a full method to analyse astigmatic outcomes using both scalar and vector values
- We suggest statistical tools suited for both normal and non-normal data
- Two calculation tools are introduced to simplify and standardise astigmatism analysis
- These are the recommended methods for reporting in JCRS

Setting standards for astigmatism analysis (editorial)

Standards for Analyzing Astigmatic Outcomes
Part I: Astigmatism Basics
Part II: Recommended Statistical Methods

June 2025 issue

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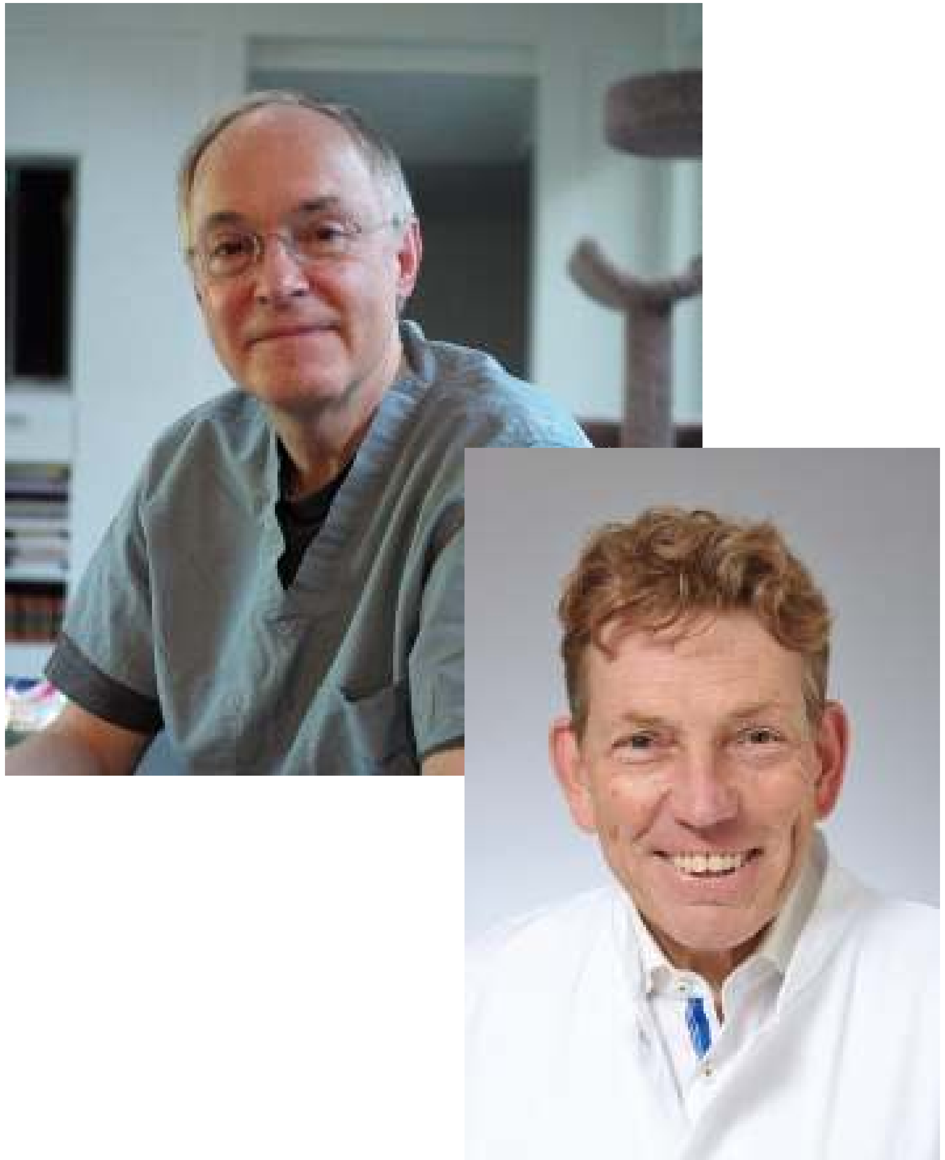

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Thank you for your attention and the invitation to Egypt

Thomas Kohnen

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