

Overview:

This Excel spreadsheet has been developed as a companion tool for the JCRS guest editorial:

Abulafia A, Koch DD, Holladay JT, Wang L, Hill WE. Pursuing perfection in intraocular lens calculations IV. Rethinking astigmatism analysis for intraocular lens-based surgery: Suggested terminology, analysis, and standards for outcome reports. *Journal of Cataract and Refractive Surgery* 2017; 44(10): 1169-1174.

It will automatically generate the following 3 figures for astigmatism analysis, with the option to evaluate the postoperative refractive astigmatism at either the spectacle or the corneal plane, plus a 4th figure displaying the postoperative spherical equivalent error:

1. A cumulative histogram of the magnitudes of the preoperative corneal astigmatism and postoperative refractive astigmatism at the spectacle plane or the corneal plane.
2. Double-angle plots of preoperative and postoperative refractive astigmatism at the spectacle plane or the corneal plane, centroid values and standard deviations, and 95% confidence ellipses of the dataset and of the centroid values.
3. Double-angle plots of postoperative refractive astigmatism prediction errors at the spectacle plane or the corneal plane, centroid values and standard deviations, and 95% confidence ellipses of the dataset and of the centroid values. Also shown in this figure are the percentages of eyes with prediction errors less than or equal to 0.25 D, 0.50 D, 0.75D, and 1.00 D.
4. A histogram of the predicted postoperative SEQ numerical errors. Also shown in this figure are the percentages of eyes with prediction errors less than or equal to 0.25 D, 0.50 D and 1.00 D; mean numerical error (MNE), standard deviation (SD), minimal prediction error (Min), maximal prediction error (Max), mean absolute prediction error (MAE) and median absolute prediction error (MedAE).

Note:

Please read these instructions in their entirety before entering any data into the Excel spreadsheet and performing astigmatism analysis for IOL-based surgery. There are certain formatting conditions that, if not followed, may create unanticipated errors. None of the fields should be left blank within the spreadsheet. If any fields are left blank, errors in data analysis will occur.

System requirements:

This Excel spreadsheet has been tested with Office 365 (for PC) using Windows 10 Pro (version 1803) with a 64-bit operating system and a 3,000 x 2,000 resolution display. It was also tested with Office 365 (for Mac, version 16.37) using the Catalina Mac OS, version 10.15.4 and a 2,560 x 1,600 resolution display. For Mac users, the Excel copy icons are not functional.

Worksheets - Overview:

There are nine worksheets within this Excel workbook. These worksheets, and the purpose of each, are the following:

1. **Data_Input** - This worksheet provides for the input of user data.
2. **A (spectacle)** – This worksheet will automatically generate a cumulative histogram of the magnitude of the preoperative corneal and postoperative refractive astigmatism at the spectacle plane.
3. **B (spectacle)** - This worksheet will automatically generate double-angle plots of the preoperative corneal astigmatism and the postoperative refractive astigmatism at the spectacle plane. Centroid values, standard deviations (SD), and 95% confidence ellipses of the centroid (red) and dataset (blue) are also calculated. Mean absolute errors with standard deviations and the number of eyes that were included are also displayed.
4. **C (spectacle)** - This worksheet will automatically generate double-angle plots of postoperative refractive astigmatism prediction errors at the spectacle plane. Centroid values, standard deviations, and 95% confidence ellipses of the centroid (red) and dataset (blue) are shown. Also, mean absolute errors with standard deviations and the number of eyes that were included are also displayed. In addition, the percentages of eyes with prediction errors less than or equal to 0.25 D, 0.50 D, 0.75D, and 1.00 D are displayed.
5. **A (cornea)** – This worksheet will automatically generate a cumulative histogram of the magnitude of the preoperative corneal and postoperative refractive astigmatism at the corneal plane.
6. **B (cornea)** - This worksheet will automatically generate double-angle plots of the preoperative corneal astigmatism and the postoperative refractive astigmatism at the corneal plane. Centroid values, standard deviations (SD), and 95% confidence ellipses of the centroid (red) and dataset (blue) are also calculated. Mean absolute errors with standard deviations and the number of eyes that were included are also displayed.
7. **C (cornea)** - This worksheet will automatically generate double-angle plots of postoperative refractive astigmatism prediction errors at the corneal plane. Centroid values, standard deviations, and 95% confidence ellipses of the centroid (red) and dataset (blue) are shown. Also, mean absolute errors with standard deviations and the number of eyes that were included are also displayed. In addition, the percentages of eyes with prediction errors less than or equal to 0.25 D, 0.50 D, 0.75D, and 1.00 D are displayed.
8. **D** - This worksheet will automatically generate A histogram of the predicted postoperative SEQ numerical errors. Also shown in this figure are the number of eyes that were included, the percentages of eyes with prediction errors less than or equal to 0.25 D, 0.50 D and 1.00 D. In addition, mean numerical error (MNE), standard deviation (SD), minimal prediction error (Min), maximal prediction error (Max), mean absolute prediction error (MAE) and median absolute prediction error (MedAE) are displayed.

9. **Terminology table** – This worksheet contains a table with the terminology that was suggested within the JCERS guest editorial mentioned above and a comparison to relevant terminology by Alpins.

The Data_Input Worksheet

There are sixteen columns (Columns A,C-F,H-L,N-R and T) where data are entered. They are arranged in the following manner:

Column Letter	Column Title	Description
A	No.	This cell generates a row number automatically.
C	Preoperative corneal astigmatism: Kflat	This cell records the pre-operative Flat K value in diopters. The allowable data range is from 30.0 D to 60.0 D.
D	Preoperative corneal astigmatism: @flat	This cell records the pre-operative Flat Meridian value. The allowable data range is from 000° to 180°.
E	Preoperative corneal astigmatism: Ksteep	This cell records the pre-operative Steep K value in diopters. The allowable data range is from 30.0 D to 60.0 D.
F	Preoperative corneal astigmatism: @steep	This cell generates the pre-operative Steep Meridian value.
H	Postoperative Refraction: Sphere	This cell records the post-operative refraction Sphere value. The allowable data range is from -30.0 D to +30.0 D.
I	Postoperative Refraction: Cylinder	This cell records the post-operative refraction Cylinder value. Both positive and negative cylinder values can be used. The allowable data range is from -30.0 D to +30.0 D.
J	Postoperative Refraction: Axis	This cell records the post-operative refraction cylinder axis value. The allowable data range is from 000° to 180°.
K	Postoperative Refraction: SEQ	This cell generates the post-operative spherical equivalent refraction value.
L	Postoperative Refraction: Adj-SEQ	This cell generates the adjusted post-operative spherical equivalent refraction value, based on the examination & adjusted lane length that were entered by the user (cells R1 and R3 respectively).
N	Predicted Postoperative Refraction: Sphere	This cell records the predicted post-operative refractive sphere value by a toric IOL calculator. The allowable data range is from -30.0 D to +30.0 D. In the case that this value is not provided by the toric IOL calculator, this cell should be left blank and the predicted post-operative spherical equivalent (SE, column N) should be entered instead.
O	Predicted Postoperative Refraction: Cylinder	This cell records the predicted post-operative refractive cylinder value by a toric IOL calculator. . Both positive and negative cylinder values can be used. The allowable data range is from -30.0 D to +30.0 D.

P	Predicted Postoperative Refraction: Axis	This cell records the predicted post-operative refractive Axis value by a toric IOL calculator. The allowable data range is from 000° to 180°.
Q	Predicted Postoperative Refraction: SE	This cell records the predicted post-operative refractive spherical equivalent (SE) value, for the selected toric IOL that was chosen. This value should be entered if no value was entered in column N. The allowable data range is from -30.0 D to +30.0 D.
R	Predicted Postoperative Refraction: Calc_Sphere	This cell generates the calculate predicted post-operative refraction Sphere, based on the values from columns O and Q.
T	Integrity check	This cell generates an integrity check for each individual row. In the case of missing data and / or if the Steep K < Flat K, an "Error" output is displayed, otherwise an "OK" output is displayed.

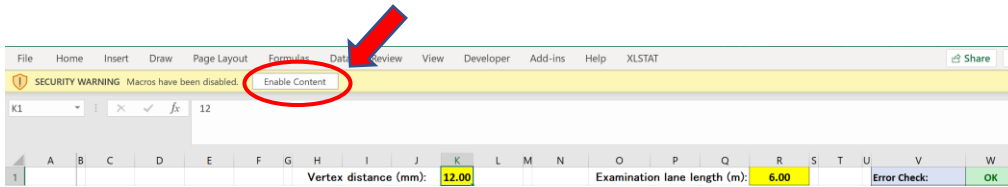
Additional input/output cells:

Cell K1	Refraction vertex distance	K1 cell records the vertex distance of the refraction in mm. The default value is set to 12.0 mm. The allowable data range is from 10.0 mm to 14.0 mm.
Cell E3	Measuring device	E3 cell records the name of the measuring device that was used to generate the input data.
Cell J3	IOL type	J3 cell records the name of the IOL type that was implanted.
Cell R1	Examination lane length	R1 cell records the examination lane length (in meters) that was used for the postoperative refraction. The allowable data range is from 2.0 meters to 10.0 meters.
Cell R3	Adjusted lane length	R3 cell records the desired adjusted lane length. The user can choose one out of three option from a list: 4 meters, 6 meters or infinity.
Cell W1	Error Check	W1 cell generates an integrity check for the whole spreadsheet. In case that there is an "Error" output on one or more of any individual row's integrity check, or if cells E3/J3 are left blank, an "Error" output will be displayed, otherwise an "OK" output is displayed.
Cell W2	Empty Rows	W2 cell generates an integrity check for the existence of any blank rows within the entered data that will lead to an incorrect display of the double angle plots diagrams. In case of a blank row an "Error" output is displayed, otherwise an "OK" output is displayed.
Cell W5	# of eyes "OK"	W5 cell generates the number of rows with an integrity check indicated as "OK".
Cell W6	# of eyes "Error"	W6 cell generates the number of rows with an integrity check indicated as "Error".

Cell W7	# of eyes Total	W7 cell generates the total number of cases that were entered by the user (W5+W6).
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To utilize this spreadsheet please follow these steps:

- I. The Data_Input Worksheet is the only point of data entry for the user. The Excel “protected sheet” option is turned on; hence, only unprotected cells are available to the user.
- II. In case a security warning regarding macros appears, the user should click “Enable Content”.



- III. Enter the desired refraction vertex distance in millimeters (cell K1).

A screenshot of the spreadsheet showing the input fields. Cell K1, containing '12.00', is circled in red with a red arrow pointing to it. Other visible fields include 'Examination lane length (m): 6.00', 'Measuring device: IOLM500', and 'IOL type: SN6ATx'.

Preoperative corneal astigmatism				Postoperative refraction					Predicted postoperative refraction				Integrit		
No.	Kflat	@flat	Ksteep	@steep	Sphere	Cylinder	Axis	SEQ	Adj-SEQ	Sphere	Cylinder	Axis	SE	Calc_Sphere	check
1	44.64	110	45.73	20	-0.25	-0.25	90	-0.38	-0.54	-0.21	-0.16	91			OK
2	42.83	90	43.66	180	0	-0.25	79	-0.13	-0.29	0.20	-0.71	1			OK

- IV. Enter the name of your Measuring device (cell E3).

A screenshot of the spreadsheet showing the 'Measuring device' field in cell E3, which contains 'IOLM500'. This cell is circled in red with a red arrow pointing to it. Other fields like 'Vertex distance (mm): 12.00' and 'IOL type: SN6ATx' are also visible.

- V. Enter the IOL type that were implanted (cell J3).

A screenshot of the spreadsheet showing the 'IOL type' field in cell J3, which contains 'SN6ATx'. This cell is circled in red with a red arrow pointing to it. Other fields like 'Measuring device: IOLM500' and 'Vertex distance (mm): 12.00' are also visible.

VI. Enter the Examination lane length in meters (cell R1).

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
1							Vertex distance (mm):			12.00							Examination lane length (m):	6.00				
2																						
3							Measuring device:			IOLM500	IOL type:						Adjusted lane length (m):	Infinity				
4																						
5	No.	Preoperative corneal astigmatism				Postoperative refraction					Predicted postoperative refraction					Integrity check						
6		Kflat	@flat	Ksteep	@steep	Sphere	Cylinder	Axis	SEQ	Adj-SEQ	Sphere	Cylinder	Axis	SE	Calc_Sphere							
7	1	44.64	110	45.73	20	-0.25	-0.25	90	-0.38	-0.54	-0.21	-0.16	91									
8	2	42.83	90	43.66	180	0	-0.25	79	-0.13	-0.29	0.20	-0.71	1									

VII. Choose the desired Adjusted lane length: 4 meters, 6 meters or Infinity (cell R3).

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
1							Vertex distance (mm):			12.00							Examination lane length (m):	6.00				
2																						
3							Measuring device:			IOLM500	IOL type:						Adjusted lane length (m):	Infinity				
4																						
5	No.	Preoperative corneal astigmatism				Postoperative refraction					Predicted postoperative refraction					Integrity check						
6		Kflat	@flat	Ksteep	@steep	Sphere	Cylinder	Axis	SEQ	Adj-SEQ	Sphere	Cylinder	Axis	SE	Calc_Sphere							
7	1	44.64	110	45.73	20	-0.25	-0.25	90	-0.38	-0.54	-0.21	-0.16	91									
8	2	42.83	90	43.66	180	0	-0.25	79	-0.13	-0.29	0.20	-0.71	1									

VIII. Insert / Edit a Record:

- a. Enter patient data starting from column C ('Kflat' column) of row number 7. Please notice, row number 7 contains data as an example, and the user should override this data. **This row should not be deleted by the "clear content" option!**
- b. For values that are outside of the allowed range, a warning box will appear.
- c. Spaces, or blank cells (except for column N or Q) are not allowed. Confirm that all data have been properly entered. If a cell is left blank, or if Ksteep is a value less than Kflat, an error message will be displayed in column T, and in cell W1. Rows with missing data are not automatically removed from the analysis, so this should be manually corrected by the user.

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
1							Vertex distance (mm):			12.00							Examination lane length (m):	6.00			Error Check:	Error
2																					Empty Rows:	OK
3							Measuring device:			IOLM500	IOL type:						Adjusted lane length (m):	Infinity				
4																						
5	No.	Preoperative corneal astigmatism				Postoperative refraction					Predicted postoperative refraction					Integrity check	# of eyes "OK":	76				
6		Kflat	@flat	Ksteep	@steep	Sphere	Cylinder	Axis	SEQ	Adj-SEQ	Sphere	Cylinder	Axis	SE	Calc_Sphere						# of eyes "Error":	2
7	1	44.64	110	45.73	20	-0.25	-0.25	90	-0.38	-0.54	-0.21	-0.16	91								# of eyes Total:	78
8	2	42.83	90	43.66	180	0	-0.25	79	-0.13	-0.29	0.20	-0.71	1									
9	3	44.29	97		7	0.5	-1	93	0.00	-0.17	0.11	-0.30	92									
10	4	43.16	89	44.64	179	0	-1	127	-0.50	-0.67	-0.35	-0.23	92									
11	5	42.19	89	43.27	179	-0.5	-0.5	90	-0.75	-0.92	-0.25	-0.02	3									

- d. Blank rows within the data entry area are not allowed. If blank rows are present within the data entry area, an error message will be displayed in cell W2. Blank data rows within the dataset will lead to an incorrect display of the double-angle plot, so this should be manually corrected by the user.

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
1							Vertex distance (mm):			12.00							Examination lane length (m):	6.00			Error Check:	OK
2																					Empty Rows:	Error
3							Measuring device:			IOLM500	IOL type:						Adjusted lane length (m):	Infinity				
4																						
5	No.	Preoperative corneal astigmatism				Postoperative refraction					Predicted postoperative refraction					Integrity check	# of eyes "OK":	77				
6		Kflat	@flat	Ksteep	@steep	Sphere	Cylinder	Axis	SEQ	Adj-SEQ	Sphere	Cylinder	Axis	SE	Calc_Sphere						# of eyes "Error":	0
7	1	44.64	110	45.73	20	-0.25	-0.25	90	-0.38	-0.54	-0.21	-0.16	91								# of eyes Total:	77
8	2	42.83	90	43.66	180	0	-0.25	79	-0.13	-0.29	0.20	-0.71	1									
9	3																					
10	4	43.16	89	44.64	179	0	-1	127	-0.50	-0.67	-0.35	-0.23	92									
11	5	42.19	89	43.27	179	-0.5	-0.5	90	-0.75	-0.92	-0.25	-0.02	3									

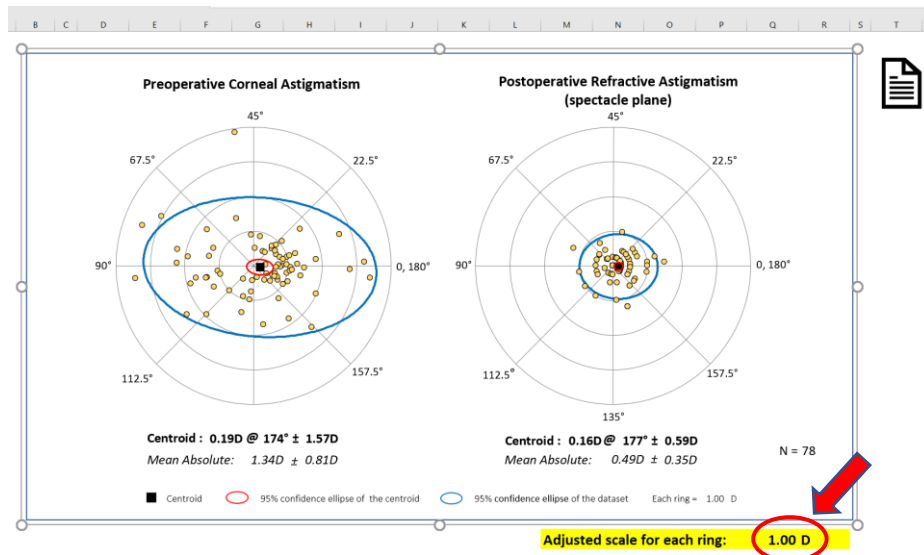
- e. Restricted Numerical Ranges: Please refer to the table above.
- f. Additional Restrictions: The Worksheet will allow a maximum input of 3000 cases.

IX. Delete Row(s) / Cell(s):

The Data_Input worksheet does not allow the user to delete rows or cells using the normal Excel Select and Delete functions. To delete entered data, the user must use the clear content option.

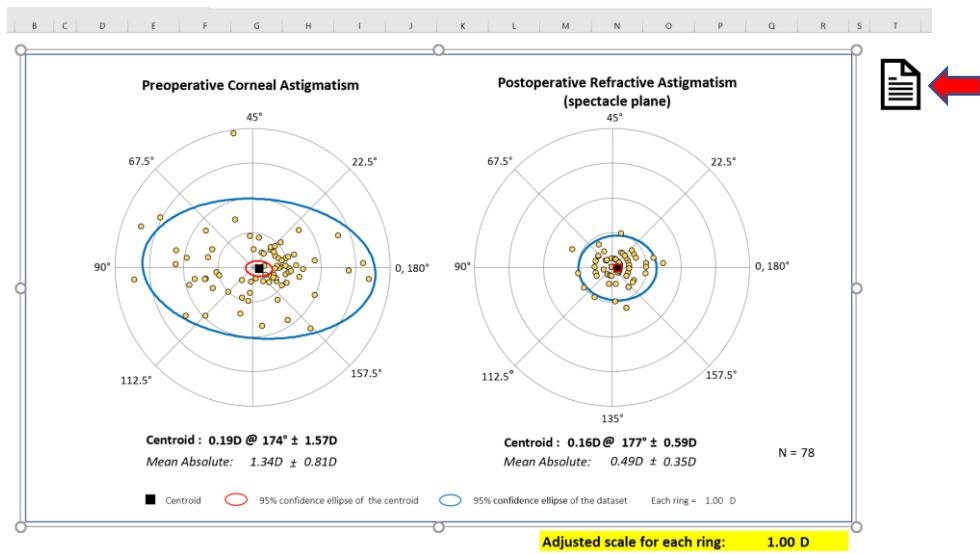
X. Worksheets A to D contains graphs / tables as mentioned above.

XI. In Worksheets B (spectacle / cornea) the user can adjust the scale for each ring of the DAP by entering the desired scale, the default scale is set to 1.00 D (Cell Q41)



These worksheets are not protected, and the user can change their style. Nevertheless, please be aware that this action is not recommended as it might unintentionally disrupt the proper presentation of the data.

To copy the graphs / tables from Worksheets A-D, the user can either use the copy icon next to it (this option will not work properly in Office for Mac), or simply select & copy it in a standard way.



For problems, or specific question, users are welcome to contact:

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End of Excel spreadsheet instructions.