A nomogram for correction of myopic astigmatism with SMILE

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Financial and Other Disclosures

I have the following financial interests or relationships to disclose:	Disclosure code
Carl Zeiss Meditec, Inc	**L, R**
Staar Surgical	L, R
Bausch + Lomb, Inc	L
Oculus, LLC	L
Acufocus	R
Medicontur	C

Consultant (C)
Employee (E)
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Patents (P)
Research support (R)

Introduction

Alió del Barrio JL, Vargas V, Al-Shymali O, Alió JL. Small incision lenticule extraction (SMILE) in the correction of myopic astigmatism: outcomes and limitations - an update. Eye Vis 2017;4:26.

"The lack of automated cyclotorsion control on the VisuMax (Carl Zeiss Meditec, Germany) and the complete surgeon-dependent centration of the treatment have raised some concerns regarding the capability of SMILE to properly correct moderate or high levels of myopic astigmatism with the current commercially available technology"

moderate or *high levels* → ≥ 0.75 D

Evidence Level IIb

Introduction

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Recommendations for enhancing results:

1) Manual correction of the static cyclotorsion for any astigmatic correction over 0.75 D
2) 10% correction increment over the original refractive cylinder value
3) Standardized refraction protocol to refine the cylinder measurement since incorrect preoperative refraction can lead to postoperative residual refractive errors

Could we improve the previous recommendations with an optimized nomogram for the myopic astigmatism correction?

Methods

Retrospective observational study
Surgeries performed at IOA Madrid (Spain)
Two experienced SMILE surgeons
Three-months follow-up

Variables in the analysis include:

- ✓ Age
- ✓ Gender
- ✓ Pre-operative astigmatism
- ✓ Optical zone diameter
- ✓ Cap diameter
- ✓ Target induced astigmatism vector (TIA)
- ✓ Surgically-induced astigmatism vector (SIA)

Marking and Cyclotorsion control:

- ✓ Marking conjunctiva with the slit-lamp
- ✓ Taking a picture of each eye with patient at sitting position for confirming the marks
- ✓ Screenshot iPad + Goniotrans (App with axis)
- ✓ Marking cornea under laser microscope (0-180°)
- ✓ Docking and manual compensation of cyclotorsion (by rotating the suction cone)

Results

Demographic Data

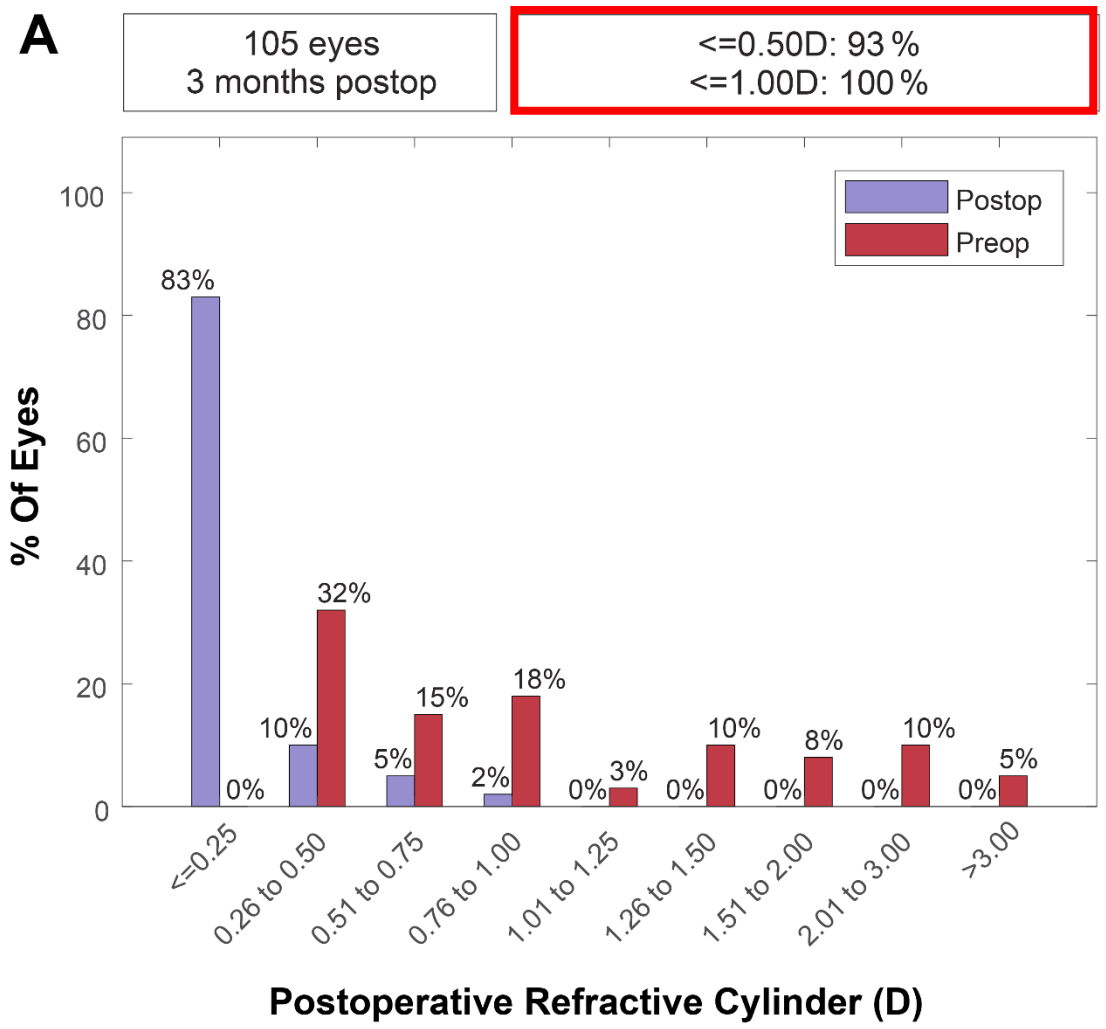
- ✓ 105 right eyes operated on SMILE were from 61 men and 44 women
- ✓ 31.66 ± 6.08 ranging from 23 to 48 years

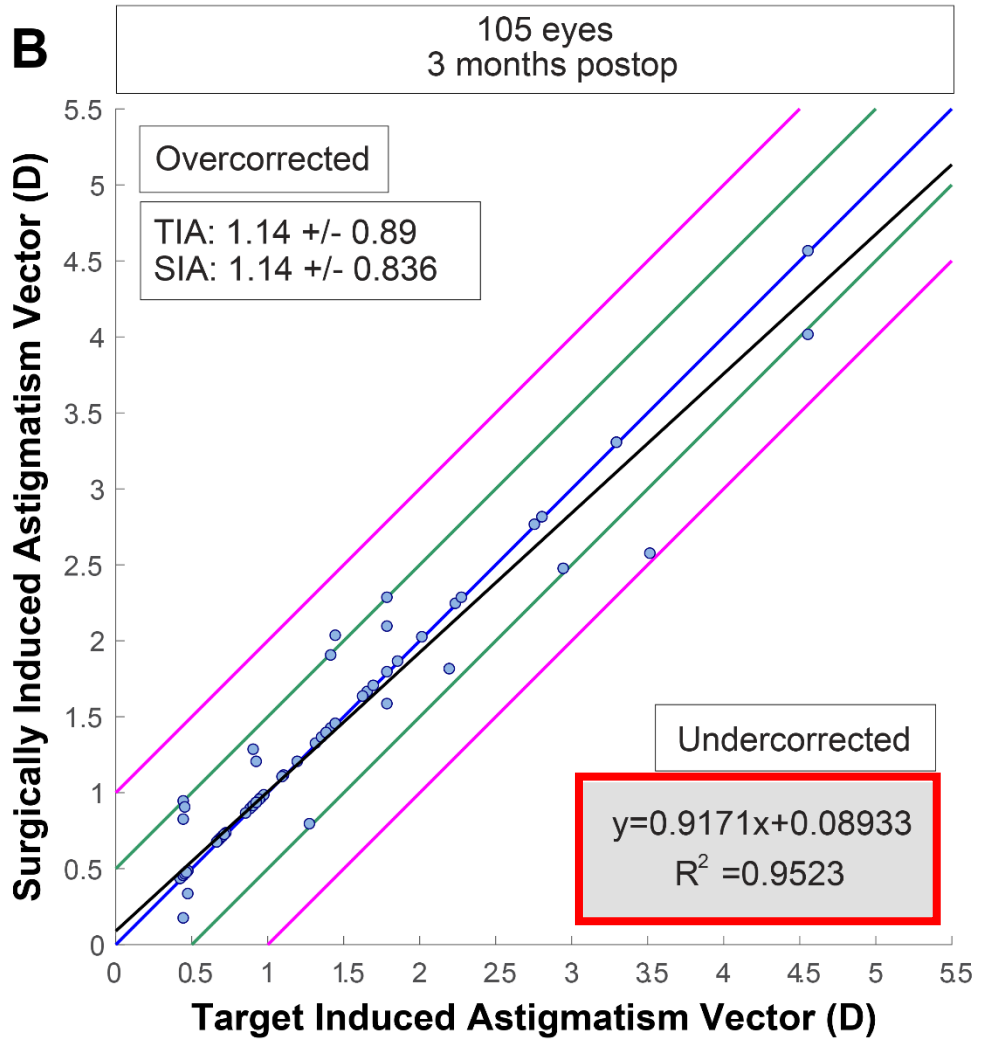
No differences in Preoperative Sphere and Cylinder between Astigmatism Classification Groups

	WTR	Oblique	ATR	Kruskal-Wallis
0.50 D				
n (%)	19 (18.1%)	5 (4.8%)	10 (9.5%)	
Cylinder (D), median (IQR)	0.5 (0)	0.5 (0)	0.5(0)	$\chi^2(2) = 0.71$, p=0.70
Sphere (D), median (IQR)	-4.25 (1.75)	-3.80 (3.50)	-4.13 (4)	$\chi^2(2) = 0.71$, p=0.70
0.75 D – 1.25 D				
n (%)	22 (21%)	7 (6.7%)	9 (8.6%)	
Cylinder (D), median (IQR)	1 (0.25)	1 (0.25)	1 (0.25)	$\chi^2(2) = 0.62$, p=0.73
Sphere (D), median (IQR)	-3.5 (2)	-2.75 (2)	-4.25 (3.13)	$\chi^2(2) = 4.74$, p=0.09
≥ 1.50 D				
n (%)	15 (14.3%)	4 (3.8%)	14 (13.3%)	
Cylinder (D), median (IQR)	2.45 (1.50)	2.00 (1.13)	2.00 (1.25)	$\chi^2(2) = 0.62$, p =0.73
Sphere (D), median (IQR)	-2.25 (3.5)	-2.13 (1.75)	-3.00 (4.13)	$\chi^2(2) = 1.39$, p=0.5

Results

Residual Cylinder and Predictability

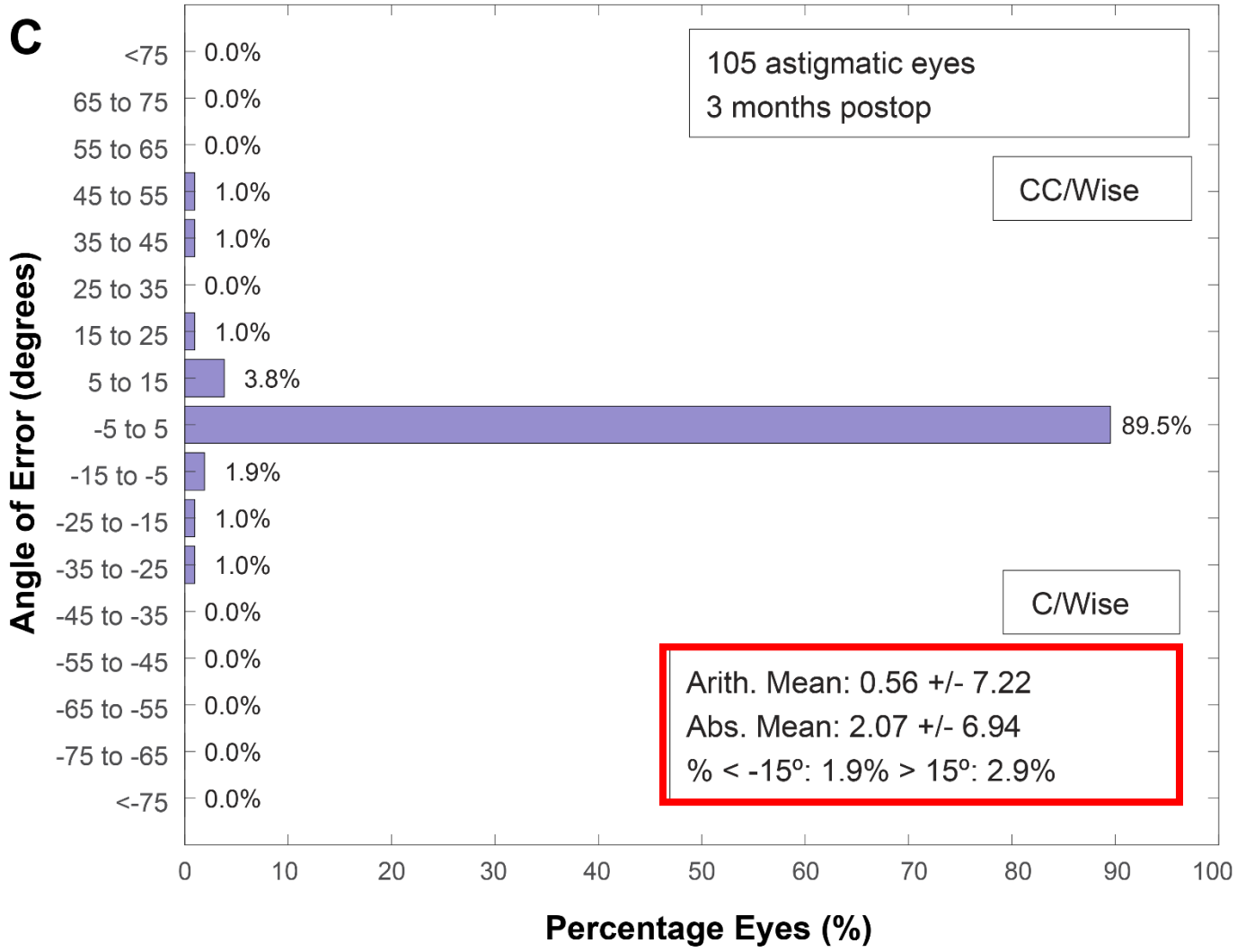




The results are only referred to astigmatism, the spherical equivalent correction was not the purpose of the study

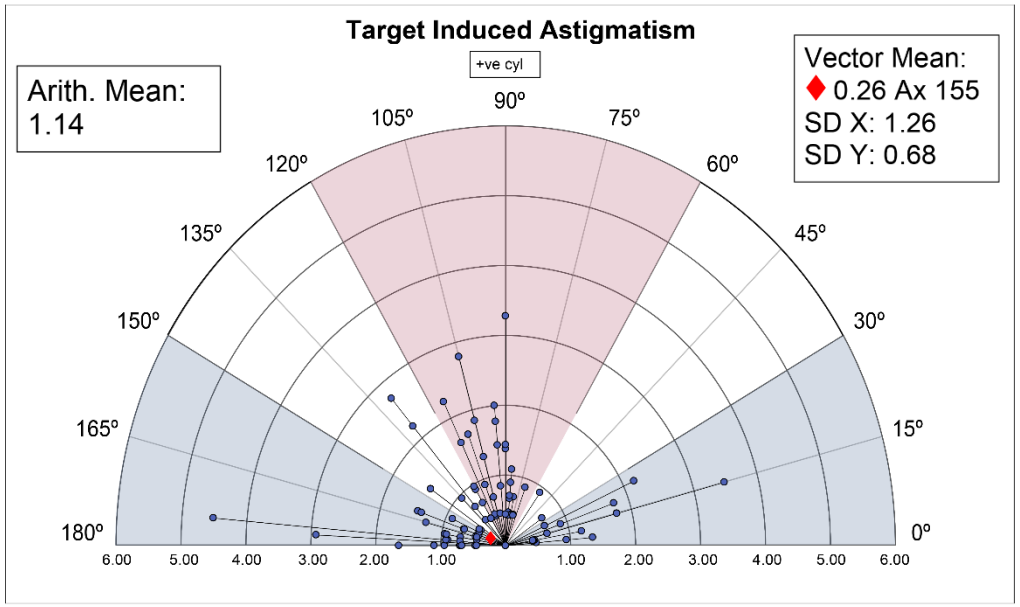
Results

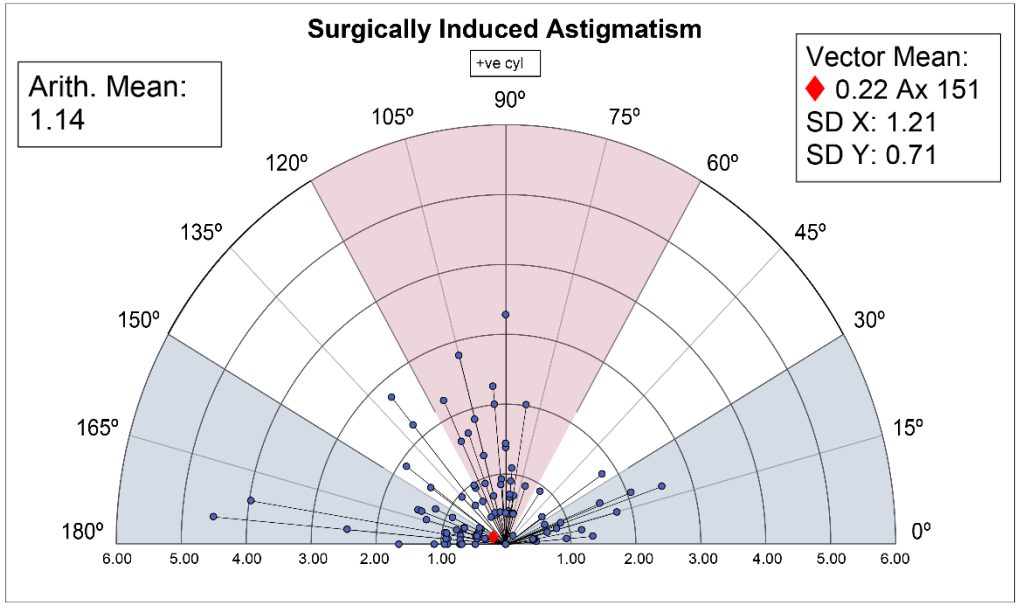
Angle of Error

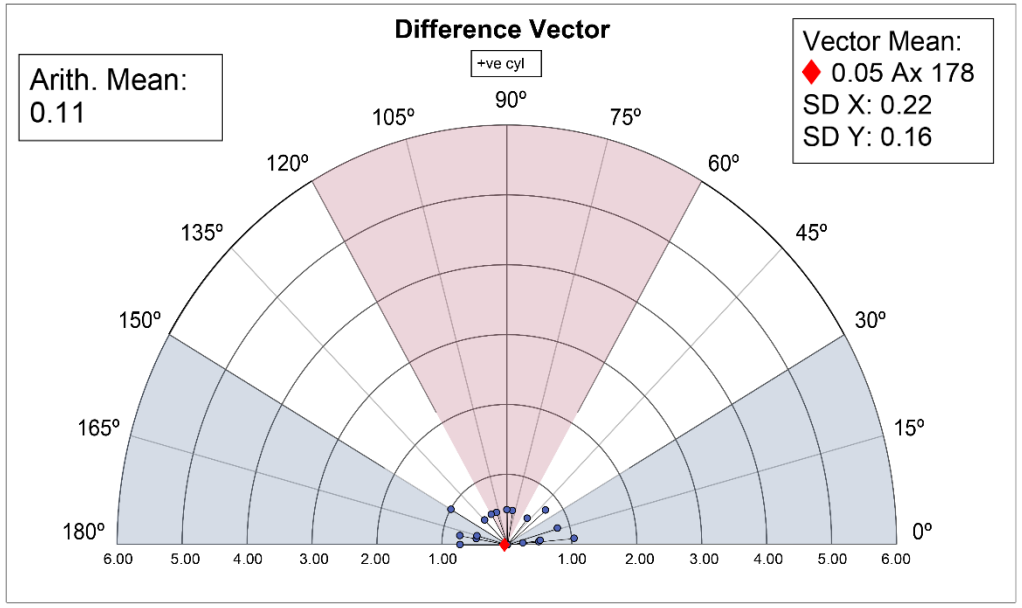


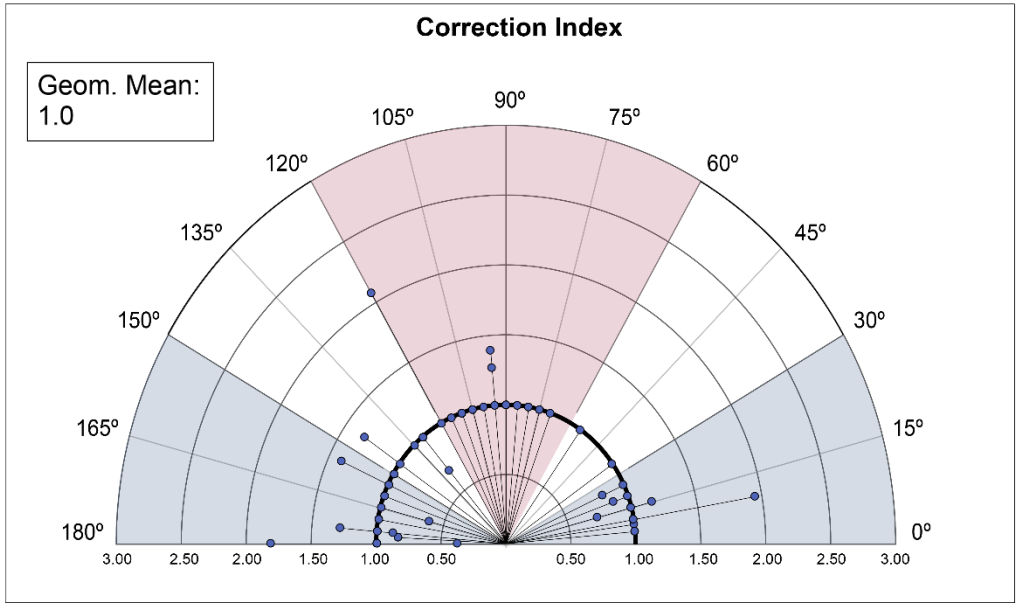
Results

Association between classification and residual









Results

Differences among Astigmatism Levels

The median of the DV was zero for the three levels of the astigmatism, but for the group ≥ 1.50 D the IQR was 0.5 D, whereas for the other two groups the IQR was zero (Significant different distributions $\chi^2(2) = 11.76$, $p = .003$)

The angle of error was not different between magnitude groups $\chi^2(2) = 0.16$, $p = .92$ or type of astigmatism groups $\chi^2(2) = 1.46$, $p = .48$

The SIA in the Higher Astigmatism group (≥ 1.50 D) was related with the preoperative astigmatism classification

Other variables such as age, sex or optical zone did not improve the prediction of the SIA

Results

Association between classification and residual

		WTR	Oblique	ATR	Fisher test
0.50 D					
Residual Cylinder	**n (%)**	3 (8.8%)	2 (5.9%)	0 (0%)	p=0.10
No Residual Cylinder	**n (%)**	16 (47.1%)	3 (8.8%)	10 (29.4%)	
0.75 D – 1.25 D					
Residual Cylinder	**n (%)**	2 (5.3%)	0 (0%)	0(0%)	p = 1.0
No Residual Cylinder	**n (%)**	20 (52.6%)	7 (18.4%)	9 (23.7%)	
≥ 1.50 D					
Residual Cylinder	**n (%)**	9 (27.3%)	1 (3%)	2 (6.1%)	P = .03
No Residual Cylinder	**n (%)**	6 (18.2%)	3 (9.1%)	12 (36.4%)	
Total					
Residual Cylinder	**n (%)**	14 (13.3%)	3(2.9%)	2(1.9%)	p = 0.07
No Residual Cylinder	**n (%)**	42(40%)	13(12.4%)	31(29.5%)	

No significant association of the Preoperative Astigmatism Classification with the presence of a Residual Astigmatism when **TOTAL SAMPLE** was analyzed

Results

Association between classification and residual

		WTR	Oblique	ATR	Fisher test
0.50 D					
Residual Cylinder	**n (%)**	3 (8.8%)	2 (5.9%)	0 (0%)	p=0.10
No Residual Cylinder	**n (%)**	16 (47.1%)	3 (8.8%)	10 (29.4%)	
0.75 D – 1.25 D					
Residual Cylinder	**n (%)**	2 (5.3%)	0 (0%)	0(0%)	p = 1.0
No Residual Cylinder	**n (%)**	20 (52.6%)	7 (18.4%)	9 (23.7%)	
≥ 1.50 D					
Residual Cylinder	**n (%)**	9 (27.3%)	1 (3%)	2 (6.1%)	P = .03
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Total					
Residual Cylinder	**n (%)**	14 (13.3%)	3(2.9%)	2(1.9%)	p = 0.07
No Residual Cylinder	**n (%)**	42(40%)	13(12.4%)	31(29.5%)	

Significant association of the Preoperative Astigmatism Classification with the presence of a Residual Astigmatism for the high astigmatism group **(≥ 1.50 D)**

Stratified analysis for astigmatism ≥ 1.50 D

The median of the Difference Vector in the WTR group was 0.49 D, 0 D in the Oblique and 0 D in the ATR

The CI median was 0.88 in the WTR whereas in the other two groups was 1 in the Oblique and 1 in the ATR

In a Multiple Lineal Regression, SIA could be predicted ($F = 153.19$, $p < .0005$) with TIA accounting for 88% of variability but with the addition of the type of astigmatism the prediction (R^2) increased up to 91%

$$SIA = 0.87*TIA + 0.14*TYPE + 0.08$$

TYPE: WTR = 0, Oblique = 1 and ATR = 2

Conclusions

No astigmatism nomogram was required for astigmatism < 1.50 D

For astigmatisms ≥ 1.50 D a nomogram can improve the results including magnitude and classification of the preoperative astigmatism

The model was used to compute the difference vector (DV) and to develop a summarizing nomogram in terms of preoperative astigmatism magnitude and classification

- ✓ Between 1,5 D and 2,5 D only overcorrection of 0,25 D in WTR
- ✓ Between 2,5 D and 4,5 D only overcorrection of 0,50 D in WTR and 0,25 D in Oblique
- ✓ No nomogram in ATR required

	WTR	Oblique	ATR
<1.5	-	-	-
1.5 – 2.5	0.25 D	-	-
2.5 – 4.5	0.50 D	0.25 D	-

Take home message

Alió del Barrio JL, Vargas V, Al-Shymali O, Alió JL. Small incision lenticule extraction (SMILE) in the correction of myopic astigmatism: outcomes and limitations - an update. Eye Vis 2017;4:26.

Recommendations for enhancing results:

1) Manual correction of the static cyclotorsion for any astigmatic correction over 0.75 D
2) No nomogram in ATR required up to 4,5 D or below 1,5 D for any type of astigmatism; from 1,5 D to 2,5 D overcorrection of 0,25 D in WTR; from 2,5 D to 4,5 D overcorrection of 0,50 D in WTR and 0,25 D in Oblique
3) Standardized refraction protocol to refine the cylinder measurement since incorrect preoperative refraction can lead to postoperative residual refractive errors

Limitations

The main limitation of the study was that corneal astigmatism was not evaluated and this is necessary in future studies for understanding the reasons of under-correction in WTR

Despite non-significant differences were found in the magnitude of preoperative astigmatism classification for the ≥ 1.50 D, median was higher in the WTR

	WTR	Oblique	ATR	Kruskal-Wallis
≥ 1.50 D				
n (%)	15 (14.3%)	4 (3.8%)	14 (13.3%)	
Cylinder (D), median (IQR)	2.45 (1.50)	2.00 (1.13)	2.00 (1.25)	$\chi^2(2) = 0.62$, p =0.73
Sphere (D), median (IQR)	-2.25 (3.5)	-2.13 (1.75)	-3.00 (4.13)	$\chi^2(2) = 1.39$, p=0.5

Future studies with higher sample and with an uniform distribution of the groups are required in order to confirm our findings

The nomogram has not still applied therefore, future studies are required to demonstrate that this nomogram might improve the astigmatism correction results

Take home message

Commonly, the Spherical Equivalent is considered for creating nomograms and this have shown in the past that some variables as: preoperative spherical equivalent, age, etc. might have influence in the postoperative residual refractive error.

Fernández J, Valero A, Martínez J, Piñero DP, Rodríguez-Vallejo M. Short-Term Outcomes of Small-Incision Lenticule Extraction (SMILE) for Low, Medium, and High Myopia. Eur J Ophthalmol 2017;27:153–9.

Our results have shown that only considering the Target Induced Astigmatism instead of the Spherical Equivalent we might obtain differences in Surgically Induced Astigmatism according to preoperative astigmatism classification. This should be studied in the future for validating this nomogram with higher samples, more uniform groups, and corneal astigmatism changes (main limitations of this retrospective analysis)