

Refractive surgery in high hyperopia. Report of 2 cases with different approaches

Cirurgia refrativa em hipermetropia alta. Relato de 2 casos com abordagens diferentes

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KEYWORDS:

Cornea: Refractive surgery: Excimer laser; Corneal topography; Hyperopia.

ABSTRACT

Two cases of patients with hyperopia with high kappa angles were described. We used different excimer laser platforms in each case to treat the refractive error. Also, we used different ablation profiles (wavefront-guided and optimized) and centration points (pupil center and halfway between corneal apex and pupil center).

PALAVRAS-CHAVE:

RESUMO

Córnea; Cirurgia refrativa; Laser excimer; Topografia da córnea; Hipermetropia.

Dois casos de pacientes com hipermetropia com ângulo kappa grande foram descritos. Diferentes plataformas de laser excimer foram usadas em cada caso para tratar o erro de refração. Além disso. diferentes perfis de ablação foram utilizados (quiados e otimizados pelo Wavefront) e pontos de centralização (centro da pupila e a metade da distância entre o ápice da córnea e o centro pupilar).

INTRODUCTION

We are at a time when the demand for visual quality has risen to a high level of excellence. Patients seeking laser refractive correction expect this and want changes in their quality of life. Refractive surgeries for farsightedness are still challenging and widely discussed¹⁻¹⁵.

Determining the treatment center is very important in refractive surgery. With recent advances, the kappa angle has become an important consideration for improving visual results. The kappa angle is defined as the angle between the visual axis and the pupillary axis¹¹. The pupillary axis is the line that passes through the center of the pupil perpendicular to the cornea. The visual axis connects the fovea with the attachment point. It is clinically identified by nasal displacement of the corneal light reflex and the center of the pupil. Farsighted patients tend to have a large kappa angle, which can lead to alignment errors during photoablation in refractive laser surgery^{12,13}. A larger kappa angle increases the risk of decentralization because of the increased distance between the pupillary center and the visual axis. Also, the pupillary center changes with pupil size under different lighting con-

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ditions. Off-center ablation can induce astigmatism and leave visual deficits such as distortion, diplopia, change in brightness, and reduced visual acuity in the patient^{14,15}. It is recommended in these cases to center the ablation profiles on or near the visual axis to reduce high-order aberrations¹⁴.

The objective of these cases is to compare and discuss the different ways to centralize refractive surgery in hyperopia. The best technique to be used has not yet been defined, however, most excimer lasers focus on the pupillary center, which can lead to unsatisfactory final results, as we will see below¹.

CASE REPORTS

Case 1

A 26 years old male patient, referred to the cornea service to evaluate refractive surgery for hyperopia. The patient's data examination is shown in Table 1A. The patient presented ocular motility and Titmus test within normal limits. Since the preoperative exam was considered normal (Figures 1 and 2), wavefront-guided Femto-LASIK procedure (pupil-centered) was the treatment option. The Scheimpflug tomography showed a kappa angle of 0.34 mm in OD and 0.40 mm in OS in this case. The excimer laser used was VISX 4 (Johnson & Johnson, New Brunswick, New Jersey, USA)) with the IFS 150 femtosecond laser (Johnson & Johnson, New Brunswick, New Jersey, USA) and the iDesign aberrometer (Johnson & Johnson, New Brunswick, New Jersey, USA). This aberrometer uses Hartmann-Shack technology and centers the treatment on the pupil center, with an iris registration eye tracker device. The patient presented normal high order aberrations (HOA) values pre--operatively (Figure 2). One month after the procedure, the patient had uncorrected visual acuity (UCVA) of 20 / 40p in both eyes and corrected visual acuity (CDVA) of 20 / 20p in both eyes, but complaining of nighttime difficulty. Upon returning, the patient maintained the complaint and presented static refraction of +1.00 S -1,00 C 90° in OD with 20/20visual acuity and +1.00 S -1.00 C 170° in OS with VA of 20/40. The topography was slightly off-center (Figure 3), with an increase in HOA (Figure 4). The vision complaints could be explained by both HOA and residual refractive error.

In the follow-up, retreatment guided by total aberrometry was performed, 3 months after the first surgery, the ablation profile suggested by Idesign (Figure 5) was in accordance with the changes we evidenced in topography.

 Table 1. A: Preoperative data of case one patient. B: Preoperative data of case two patient

1A	OD	OS
Cycloplegic Refraction	+5.00 S -0.50 C 165	+5.75 S -0.50 C 005
Corrected Visual Acuity (Snellen)	20/20	20/20
Biomicroscopy	Normal	Normal
Fundoscopy	Normal	Normal
Thinnest Pachymetry	$520~\mu$	520μ
Posterior Elevation	Normal	Normal
Corneal topography	Symmetrical regular with-the rule astigmatism	Symmetrical regular with-the rule astigmatism
Flatter keratometry	40 D	40 D
Steeper keratometry	41 D	41 D
1B	OD	OS
Cyclopegic Refraction	+5,00 S -1.25 C 150	+5.25 S -1.25 C 145
Corrected Visual Acuity (Snellen)	20/20	20/20
Biomicroscopy	Normal	Normal
Fundoscopy	Normal	Normal
Thinnest Pachymetry	605μ	$604~\mu$
Posterior Elevation	Normal	Normal
Corneal topography	Symmetrical regular and oblique astigmatism	Symmetrical regular and oblique astigmatism
Flatter keratometry	40 D	40 D
Steeper keratometry	42 D	42 D

We opted for re-lifting the flap and perform a new wavefront-guided treatment, centered in the pupil as well.

After 1 month the patient had flat refraction in both eyes and UCVA of 20/20 in both eyes. At this moment, the patient has no complaints, with a decrease in HOA (Figure 6), especially in coma. The corneal profile improved after surgery (Figure 7), the keratometric values stabilized (as seen in Table 2A) 3 months after surgery.

Case 2

A 30 years old male patient, referred to the cornea service to evaluate refractive surgery for hyperopia. The patient's data examination is shown in Table 1B.

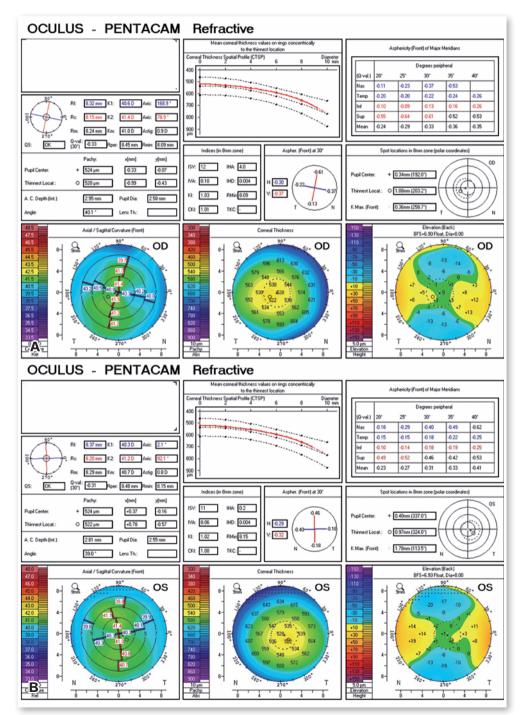


Figure 1. A/B: Pre-operative tomography exam of case one patient.

eOftalmo. 2021;7(4):189-200.

191



The patient presented ocular motility and Titmus test within normal limits. Since the preoperative exam was considered normal (Figures 8 and 9), optimized Femto-LASIK (centered on corneal apex) was performed using the FS200 laser (Alcon, Fort Worth, TX, USA). The excimer laser was the EX500 Wavelight laser (Alcon, Fort Worth, TX, USA). The kappa angle was 0.96 mm (Figure 9) measured by the Allegro Topolyzer Vario device (Alcon, Fort Worth, TX, USA), so it was decided to center halfway between the corneal apex and the pupillary center. The ablation profile and treatment planning can be seen in Figure 10. After the procedure, the patient had UCVA of 20/20 in both eyes with static refraction in OD: plane -0.25 C 050 and OE: plane -1.25 C 180, with no nocturnal complaints and normal corneal topography (Figure 11).

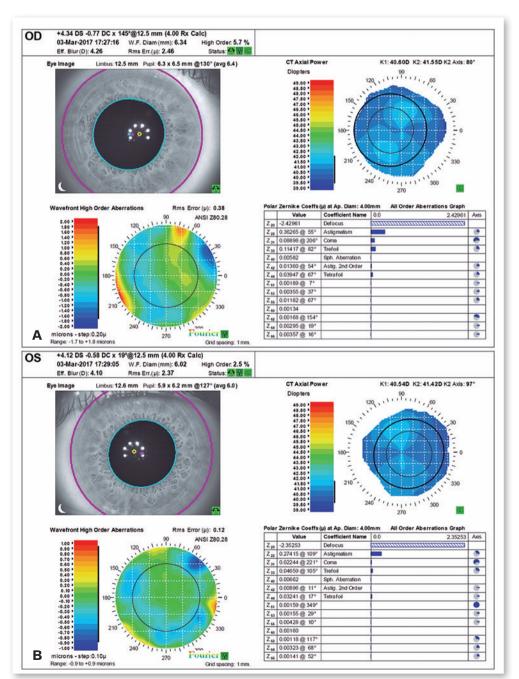


Figure 2. A/B: Pre-operative HOA of case one patient.



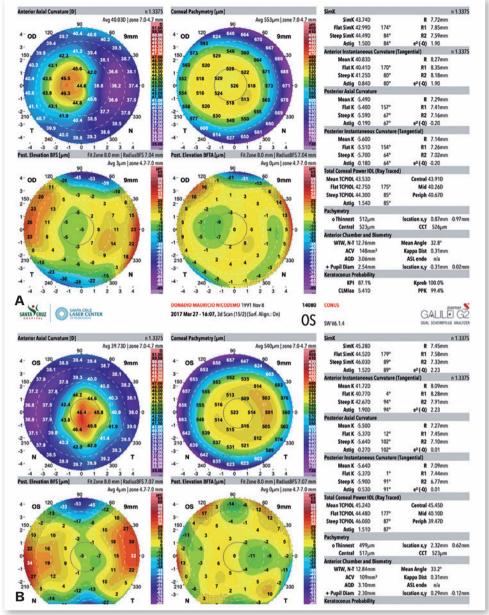


Figure 3. A/B: Post-operative topography exam of case one patient.

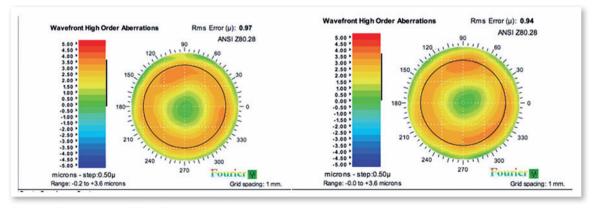


Figure 4. Post-operative HOA of case one patient.



DISCUSSION

There is a discussion whether you should center your refractive surgery in the Purkinje reflex or the pupil center, but most of the literature recommends that centralization be performed first on the Purkinje reflex or at the apex of the cornea, using the value of the kappa angle measured by the tomography or topography. It can also be centered on the distance between the center of the pupil and the corneal reflex, especially in patients with a large kappa angle. The reports above demonstrate an important variation in centralization¹.

Literature results about centralization

Nepomuceno et al carried out a study with hypermetropic patients. He performed LASIK, focusing on the coaxial reflex, in 61 patients with spherical equi-

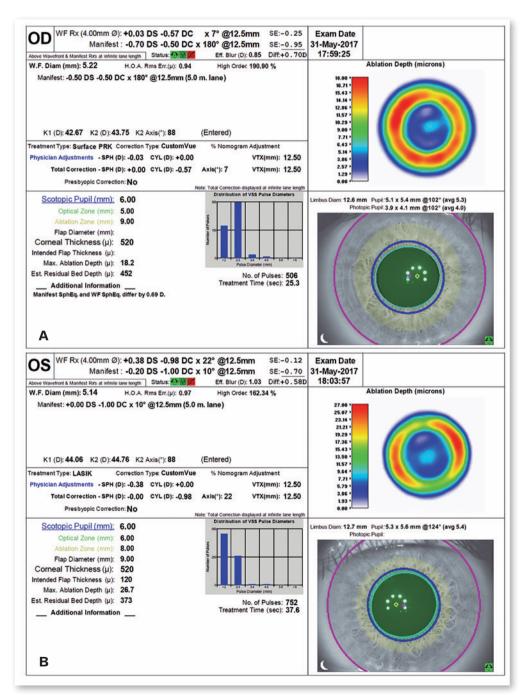


Figure 5. A/B: HOA retreat planning.



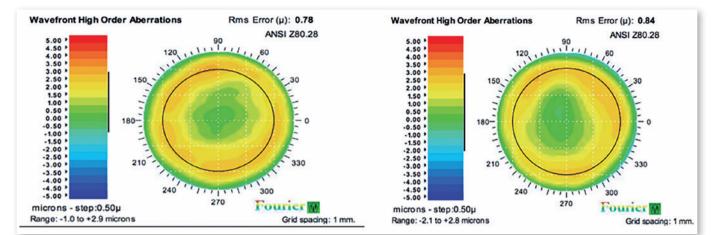


Figure 6. Final HOA result.

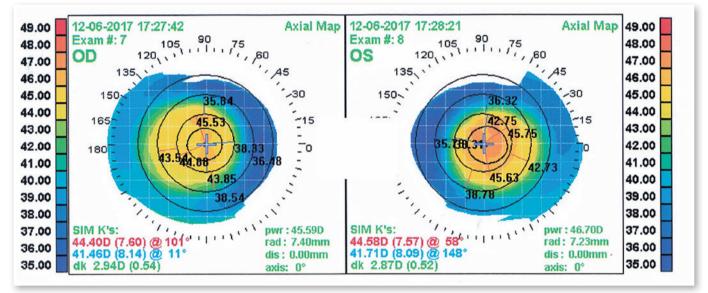


Figure 7. Final topography result.

Table 2. A: Pos operative data of case one patient

	OD	OS
Cyclopegic Refraction	PLANE	PL
Corrected Visual Acuity (Snellen)	20/20	20/20
Biomicroscopy	Normal	Normal
Fundoscopy	Normal	Normal
Posterior Elevation	Normal	Normal
Corneal topography	Increased central curvature	Increased central curvature
Flatter keratometry	43.02 D	44.06 D
Steeper keratometry	44.06D	44.76D

eOftalmo. 2021;7(4):189-200.



Table 2. B: Pos operative data of case two patient

	OD	OS
Cyclopegic Refraction	PLANE -0,25 C 500	PLANE -1,25 C 1800
Corrected Visual Acuity (Snellen)	20/20	20/20
Biomicroscopy	Normal	Normal
Fundoscopy	Normal	Normal
Posterior Elevation	Normal	Normal
Corneal topography	Increased central curvature	Increased central curvature
Flatter keratometry	45 D	45.5 D
Steeper keratometry	46 D	46.5 D

Anterior Axial Curvature [D]	n 1.3375	Corneal Pachymetry [µm]		SimK					n 1.3375
Av	g 40.63D zone 7.0-4.7 mm		Avg 665µm zone 7.0-4.7 mm	SimK	1.38D		R	8.16mm	
90	51.00	90	Lim.	Flat SimK	10.75D	230	81	8.28mm	
4- OD 120 40.7 39.9 39.2 10	9mm 80.80	4- OD 120 745 756 768	50 9mm	Steep SimK		113°	R2	8.03mm	
410 30.	49.00	724	110 440		1.250	1139	e2 (-Q)		
3-	37.1 48.00	3- 682 688	771 #88	Anterior Instan					n 1.3375
	37.0-30 47.00	150 665	763 30 400	Mean K		irvature (8.19mm	11.3373
405/ 415	46.50	2- 697 / 649 / 695	680 100 490	Flat K		202		8.31mm	
	39.4 \ 37.1 45.00	1- 625 638	681 757			1109			
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-1- 41.4 41.7	40.4 37.4 41.00	-1- 610 621	668 / 749	Mean K		1000		6.78mm	
-2- 40.0 40.8 41.4	0 38.4 39.50	666 630	657 / 733	Flat K		13°		6.89mm	
210 40.0 40.8 41.0 41.3	330 32.00	210 672 638 640 649		Steep K		103°		6.68mm	
-3- T 40.0	39.3 30.00	-3- 688	719 \$78		-0.19D	103°	e² (-Q)	0.28	_
T 40.0 39.8 39.	7 N 3338	697	712 N 388	Posterior Instan		urvature			
-4- 240 39.8 39.7 39.7 39.7	300 35.50	-4 240 685 700		Mean K	-5.87D		R	6.81mm	
4 3 2 1 0 1 2	2 3 4 35.00	4 3 2 1 0 1	2 3 4 720	Flat K	-5.59D	18°	R1	7.15mm	
Post. Elevation BFS [µm] Fit Zone 8.	.0 mm RadiusBFS 6.93 mm	Post. Elevation BFTA [µm] Fit Z	one 8.0 mm RadiusBFS 6.93 mm	Steep K	-6.15D	108°	R2	6.50mm	
	Avg -Sum zone 4.7-7.0 mm		Avg -0µm zone 4.7-7.0 mm	Astig	-0.56D	108°	e ² (-Q)	0.28	
90	pm.	90	Pm 65	Total Corneal P		Ray Traced			
4- OD 120 -21 -9 9	50 9mm	4- OD 120 .7 6 15	60 9mm	Mean TCPIOL			Central 4	40.38D	
27	45		8 9mm	Flat TCPIOL		25°		40.64D	
323 -16	50 9mm	3. 1. 1. 1	40	Steep TCPIOL		115°	Periph		
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Δ4- 240 3 4		240	300		3.4%		Kprob		
A 4 3 2 1 0 1 2	2 3 4	4 3 2 1 0 1	2 3 4	CLMIaa	0.39D		PPK	0.4%	
Anterior Axial Curvature [D]	n 1.3375	Corneal Pachymetry [µm]		SimK					n 1.3375
90 Av	rg 40.94D zone 7.0-4.7 mm	90	Avg 668µm zone 7.0-4.7 mm	SimK	\$1.71D		R	8.09mm	
	51.00		\$00	Flat SimK		155°		8.26mm	
4- OS 120 39.7 40.0 40.1 40.	50 9mm	4- OS 120 765 765 756	737 9mm 410	Steep SimK	12.55D	65°	R2	7.93mm	
39.7	40.7 49.00	3- 768	737 9mm		1.68D	65°	e ² (-Q)		
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150, ^{39,6} 39,9 ^{40,9} 41,7 ²⁻ 38,4 39,9 41,6 42,5		2- 779 698, 631 618	653 709	Mean K	10.84D	630	R R1 R2	8.26mm 7.97mm	
150, 39.6 39.9 40.9 41.7 2- 38.4 39.9 41.6 1 37.8 39.8 40.8	9 40.6 40.0 41.5 40.4 45.00	2- 779 / 698 / 631 618 1- 1764 / 681 / 635	653 709	Mean K Flat K Steep K	10.84D	100	R R1	8.26mm 7.97mm	
150, ^{39,6} 39,9 ^{40,9} 41,7 ²⁻ 38,4 39,9 41,6 42,5	9 40.6 40.0 41.5 40.4 45.00 40.6 40.0	2- 779 698, 631 618	653 709	Mean K Flat K Steep K	40.84D 42.36D 1.51D	630	R R1 R2	8.26mm 7.97mm	
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$\begin{array}{cccccccccccccccccccccccccccccccccccc$	20.6 40.8 41.5 40.4 40.9 40.2 40.8 39.9 40.1 33.0 40.2 33.0 40.2 33.0 40.2 33.0 40.2 33.0 40.2 33.0 40.2 33.0 40.2 33.0 40.2 33.0 40.2 33.0 40.2 33.0 40.2 33.0 40.2 33.0 40.2 33.0 40.2 33.0 40.2 33.0 40.2 33.0 40.2 33.0 40.2 33.0 40.2 3.0 40.2 3.0 40.2 3.0 40.2 3.0 40.2 3.0 40.2 3.0 40.2 3.0 40.2 3.0 40.2 3.0 40.2	201 779 658 631 618 1 784 681 635 617 617 1 784 681 635 617 617 1 784 681 635 617 616 1 724 661 615 610 210 726 661 649 640 3 N 724 720 706 705 4 3 2 1 0 1	653 709 642 656 653 680 628 681 633 685 690 530 693 693 709 709 2 3 4 400	Mean K Flat K. Steep K Astig Posterior Axial Mean K Flat K Steep K Astig Posterior Instar Mean K Flat K	40.84D 42.36D 1.51D Curvature -6.02D -5.88D -6.16D -0.27D taneous C -5.95D -5.70D	63° 63° 174° 84° 84°	R R1 R2 e ² (-Q) R R1 R2 e ² (-Q) (Tangential) R R1	8.26mm 7.97mm 0.19 6.64mm 6.80mm 6.80mm 0.47 6.72mm 7.02mm	
150, 30, 39, 40, 41, 41, 41, 41, 41, 41, 41, 41, 41, 41	40.6 (41.5 40.4 (40.2 (4	201 779 658 631 618 1 784 681 635 617 617 1 784 681 635 617 617 1 784 681 635 617 616 1 724 661 615 610 210 726 661 649 640 3 N 724 720 706 705 4 3 2 1 0 1	553 709 642 666 553 680 662 681 633 665 692 709 693 709 693 709 693 709 693 709 693 70 500 2 300 2 300 2 300 2 300 2 300 2 300 2 300 2 30 2 668 300 300 2 300 2 300 2 300 2 300 2 300 2 300 2 300 2 300 2 300 2 300 2 300 2 300 2	Mean K Flat K. Steep K. Astig Posterior Axial Mean K Flat K Steep K Astig Posterior Instar Mean K Flat K Flat K Steep K	40.84D 42.36D 1.51D Curvature 4.02D 5.88D 4.16D 0.27D taneous C 5.95D 5.70D 4.20D	63° 63° 174° 84° 84° 84° 164° 74°	R R1 R2 e ² (-Q) R R1 R2 e ² (-Q) (Tangential) R R1 R2	8.26mm 7.97mm 0.19 6.64mm 6.80mm 6.50mm 0.47 6.72mm 6.45mm	
150, 30, 39, 40, 41, 41, 41, 41, 41, 41, 41, 41, 41, 41	20.6 40.8 41.5 40.4 40.9 40.2 40.8 39.9 40.1 33.0 40.2 33.0 40.2 33.0 40.2 33.0 40.2 33.0 40.2 33.0 40.2 33.0 40.2 33.0 40.2 33.0 40.2 33.0 40.2 33.0 40.2 33.0 40.2 33.0 40.2 33.0 40.2 33.0 40.2 33.0 40.2 33.0 40.2 33.0 40.2 33.0 40.2 3.0 40.2 3.0 40.2 3.0 40.2 3.0 40.2 3.0 40.2 3.0 40.2 3.0 40.2 3.0 40.2 3.0 40.2	201 779 658 631 618 1 784 681 635 617 617 1 784 681 635 617 617 1 784 681 635 617 616 1 724 661 615 610 210 726 661 649 640 3 N 724 720 706 705 4 3 2 1 0 1	553 709 642 696 500 632 680 - 0 633 685 330 699 T 500 2 693 68 1 1 693 693 T 1 693 500 2 3 4 699 T 1 1 1 690 3 4 5 6 1 1 690 3 655 5 6 1	Mean K Flat K Steep K Astig Posterior Axial Mean K Steep K Astig Posterior Instar Mean K Flat K Steep K Astig	40.84D 42.36D 1.51D Curvature 4.02D 5.88D 4.16D 0.27D taneous C 5.95D 5.70D 4.20D 0.51D	63° 63° 174° 84° 84° 84° 84° 164° 74° 74° 74°	R R1 R2 e ² (-Q) R R1 R2 e ² (-Q) (Tangential) R R R1 R2 e ² (-Q)	8.26mm 7.97mm 0.19 6.64mm 6.80mm 6.50mm 0.47 6.72mm 6.45mm	
150, 30,6 39,9 40,9 41,7 25,4 39,9 41,8 42,5 17,8 39,8 40,8 40,9 41,0 18,0 40,4 42,0 41,0 18,0 40,4 42,0 41,0 10,0 40,4 42,0 41,0 20,0 40,4 42,0 41,0 40,7 40,5 40,4 20,0 40,7 40,7 40,5 40,4 20,0 40,4 40,7 40,7 40,5 40,4 20,0 40,4 40,7 40,7 40,7 40,5 40,4 20,0 40,4 40,7 40,7 40,5 40,4 20,0 40,4 40,7 40,7 40,7 40,5 40,4 20,0 40,4 40,7 40,7 40,5 40,4 40,7 40,7 40,5 40,4 40,7 40,7 40,5 40,4 40,7 40,7 40,5 40,4 40,7 40,7 40,5 40,4 40,7 40,7 40,5 40,4 40,7 40,7 40,5 40,4 40,7 40,7 40,7 40,5 40,4 40,7 40,7 40,7 40,7 40,7 40,7 40,7	40.6 40.9 40.2	201 775 684 631 618 785 681 635 67 0 789 677 627 67 0 749 663 615 810 749 663 643 640 3 N 734 700 706 705 4 3 2 1 0 Post Elevation BFIA (pm) Fit Z	642 656 642 656 642 656 643 680 -0 643 681 643 685 530 645 757 645 681 645 6	Mean K Flat K. Steep K Astig Posterior Axial Mean K Flat K Steep K Astig Posterior Instar Mean K Flat K Steep K Astig Total Corneal P	40.84D 42.36D 1.51D Curvature 6.02D 5.88D 6.16D 0.27D taneous C 5.95D 5.70D 6.20D 0.51D www.IOL (F	63° 63° 174° 84° 84° 84° 84° 164° 74° 74° 74°	R R1 R2 e ² (-Q) R R1 R2 e ² (-Q) (Tangential) R R1 R2 e ² (-Q) ()	8.26mm 7.97mm 0.19 6.64mm 6.80mm 6.80mm 0.47 6.72mm 7.02mm 6.45mm 0.47	
150, 50, 50, 50, 50, 50, 50, 50, 50, 50,	40.6 40.9 40.2	2017 73 684 631 633 754 681 655 67 0 759 686 61 649 660 749 666 61 649 660 749 666 61 649 660 749 720 700 705 70 726 61 649 660 70 700 705 70 700 705 70 705 700 705 700 705 700 705 700 705 700 705 700 705 700 705 700 705 700 705 700 705 700 705 700 705 700 705 700 705 700 705 700 705 700 700	553 709 642 666 553 680 623 681 633 685 5300 530 685 T 330 530 683 T 330 54 688 T 300 2 3 4 ane 8.0 mm [RadiusBF5 6.81 mm Arg 0µm [zone 4.7.7 0m]	Mean K Flat K Steep K Astig Posterior Axial Mean K Flat K Steep K Astig Posterior Instar Mean K Flat K Steep K Astig Total Corneal P Mean TCPIOL	40.84D 42.36D 1.51D Curvature 6.02D 5.88D 6.16D 0.27D taneous C 5.95D 5.70D 6.20D 0.51D wer IOL (F 40.66D	63° 63° 174° 84° 84° 84° 164° 74° 74° 74° 74° Ray Traced	R R1 R2 e ² (-Q) R R1 R2 e ² (-Q) (Tangenta) R R1 R2 e ² (-Q)) (Central 4	8.26mm 7.97mm 0.19 6.64mm 6.80mm 6.80mm 0.47 6.72mm 7.02mm 6.45mm 0.47 40.50D	
150, 93, 5, 39, 9, 40, 3, 41, 7, 41, 5, 39, 40, 3, 41, 5, 42, 5, 10, 10, 10, 10, 10, 10, 10, 10, 10, 10	40.6 40.9 40.2	201 775 684 631 618 785 681 635 67 0 789 677 627 67 0 749 663 615 810 749 663 643 640 3 N 734 700 706 705 4 3 2 1 0 Post Elevation BFIA (pm) Fit Z	642 656 642 656 642 656 643 680 -0 643 681 643 685 530 645 757 645 681 645 6	Mean K Flat K Steep K Astig Posterior Axial Mean K Flat K Steep K Astig Posterior Instan Mean K Flat K Steep K Astig Total Corneal P Mean TCPIOL Flat TCPIOL	40.84D 42.36D 1.51D Curvature -6.02D -5.88D -6.16D -0.27D traneous C -5.95D -5.70D -6.20D -0.51D wer IOL (F 40.66D 39.80D	63° 63° 174° 84° 84° 84° 164° 74° 74° 74° 74° Ray Traced	R R1 R2 e ² (-Q) R R1 R2 e ² (-Q) (Tangential) R R1 R2 e ² (-Q) () Central Mid	8.26mm 7.97mm 0.19 6.64mm 6.80mm 6.50mm 0.47 6.72mm 6.45mm 0.47 40.50D 40.88D	
150. 30.6 39.9 40.9 41.7 25.4 59.9 41.8 42.5 17.8 59.8 40.8 40.9 41.0 10.7.8 59.8 40.8 40.9 41.0 10.4 42.0 41.3 42.5 10.4 42.0 42.5 41.3 20.9 41.5 42.0 42.1 41.5 20.9 41.5 42.0 42.1 41.5 20.9 41.5 42.0 40.7 40.5 40 4. 0.7 40.7 40.7 40.5 40 4. 0.5 120 40.7 40.7 40.5 40 5. 0.5 120 40.5 40.5 40.5 40.5 40.5 40.5 40.5 40.	20.6 41.5 40.9 40.2	20173 684 631 618 1754 681 635 67 0 1754 681 635 67 0 1754 681 643 640 210 726 681 643 640 210 726 681 643 640 210 726 681 643 640 210 726 700 705 4 3 2 10 700 705 4 3 2 70 700 705 4 3 7 7 0 700 705 7 7 7 7 0 700 705 7 7 7 7 0 700 705 7 7 7 0 700 705 7 7 7 7 0 700 705 7 7 7 7 7 0 700 705 7 7 7 7 7 0 705 7 7 7 7 7 7 7 7 0 705 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7	642 656 642 656 642 656 643 680 -0 643 681 643 685 530 645 757 645 681 645 6	Mean K - Flat K. Steep K. Astig Posterior Axial Mean K Steep K. Astig Posterior Instan Mean K Flat K Steep K. Astig Total Corneal P Mean TCPIOL Steep TCPIOL Steep TCPIOL	40.84D 42.36D 1.51D Curvature 4.02D 5.88D 0.27D taneous C 5.95D 5.70D 4.20D 0.51D 5.95D 5.70D 4.20D 0.51D 5.95D 4.20D 4.53D	63° 63° 174° 84° 84° 84° 84° 164° 74° 74° 74° Ray Traced	R R1 R2 e ² (-Q) R R1 R2 e ² (-Q) (Tangenta) R R1 R2 e ² (-Q)) (Central 4	8.26mm 7.97mm 0.19 6.64mm 6.80mm 6.50mm 0.47 6.72mm 6.45mm 0.47 40.50D 40.88D	
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	20.6 41.5 40.9 40.2	2007 779 699, 631 618 1764 681/ 635 607 4 1763 671 622 607 4 1763 671 622 610 2007 20 661 649 640 3 N 733 2 -1 0 1 Post Elevation BFIA jum) Fit Z 4 OS 120 17 6 3 D 720 70 70 705 705 4 OS 120 17 6 3 D 720 70 70 705 705 4 OS 120 17 6 3 D 720 70 70 705 705 4 OS 120 705 705 4 OS 120 705 705 4 OS 120 705 705 4 OS 120 705 705 7 O	642 656 642 656 642 656 643 680 -0 643 681 643 685 530 645 757 645 681 645 6	Mean K. Flat K. Steep K. Astig Posterior Axial Mean K. Flat K. Steep K. Astig Total Corneal P. Mean TCF/OL. Steep TCF/OL. Astig	40.84D 42.36D 1.51D Curvature -6.02D -5.88D -6.16D -0.27D traneous C -5.95D -5.70D -6.20D -0.51D wer IOL (F 40.66D 39.80D	63° 63° 174° 84° 84° 84° 164° 74° 74° 74° 74° Ray Traced	R R1 R2 e ² (-Q) R R1 R2 e ² (-Q) (Tangential) R R1 R2 e ² (-Q) () Central Mid	8.26mm 7.97mm 0.19 6.64mm 6.80mm 6.50mm 0.47 6.72mm 6.45mm 0.47 40.50D 40.88D	
150. 30.6 39.9 40.9 41.7 25.4 59.9 41.8 42.5 17.8 59.8 40.8 40.9 41.0 10.7.8 59.8 40.8 40.9 41.0 10.4 42.0 41.3 42.5 10.4 42.0 42.5 41.3 20.9 41.5 42.0 42.1 41.5 20.9 41.5 42.0 42.1 41.5 20.9 41.5 42.0 40.7 40.5 40 4. 0.7 40.7 40.7 40.5 40 4. 0.5 120 40.7 40.7 40.5 40 5. 0.5 120 40.5 40.5 40.5 40.5 40.5 40.5 40.5 40.	20.6 41.5 40.9 40.2	20173 684 631 618 1754 681 635 67 0 1754 681 635 67 0 1754 681 643 640 210 726 681 643 640 210 726 681 643 640 210 726 681 643 640 210 726 700 705 4 3 2 10 700 705 4 3 2 70 700 705 4 3 7 7 0 700 705 7 7 7 7 0 700 705 7 7 7 7 0 700 705 7 7 7 0 700 705 7 7 7 7 0 700 705 7 7 7 7 7 0 700 705 7 7 7 7 7 0 705 7 7 7 7 7 7 7 7 0 705 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7	642 656 642 656 642 656 643 680 -0 643 681 643 685 530 645 757 645 681 645 6	Mean K. Flat K. Steep K. Astig Posterior Axial Mean K. Flat K. Steep K. Astig Total Corneal P. Mean TCPIOL Steep TCPIOL. Steep TCPIOL.	40.84D 42.36D 1.51D Curvature 4.02D 5.88D 4.16D -0.27D taneous C 5.95D -5.70D 4.51D 5.70D 4.51D 5.70D 4.51D 5.70D 4.51D 5.70D 4.51D 5.70D 4.51D 5.70D 4.51D 5.70D 4.51D 5.70D 4.52D 5.70D	63° 63° 174° 84° 84° 84° 84° 164° 74° 74° 74° Ray Traced	R R1 R2 e ² (-0) R R1 R2 e ² (-0) (Tangenta) R1 R2 e ² (-0)) Central Mid 4	8.26mm 7.97mm 0.19 6.64mm 6.80mm 6.50mm 0.47 6.72mm 0.47 6.45mm 0.47 40.50D 40.88D 41.01D	
150, 20.6 39.9 40.9 41.7 2 54, 39.9 41.8 42.5 1 7,8 39.8 40.8 40.9 41.0 1 7,8 39.8 40.8 40.9 41.0 1 40,4 42.0 40.7 40.7 40.4 2 40,4 40.7 40.7 40.7 40.4 4 05 123 40.7 40.7 40.4 4 05 123 40.7 40.7 40.4 90 4 05 123 40.7 40.7 40.4 91 4 05 123 40.7 40.7 40.7 40.4 91 4 05 123 40.7 40.7 40.7 40.4 91 4 05 123 40.7 40.7 40.7 40.7 40.7 40.7 40.7 40.7	20.6 41.5 40.9 40.2	20173 684 631 618 1754 681 635 67 0 1754 681 635 67 0 1754 681 643 640 210 726 681 643 640 210 726 681 643 640 210 726 681 643 640 210 726 700 705 4 3 2 10 700 705 4 3 2 70 700 705 4 3 7 7 0 700 705 7 7 7 7 0 700 705 7 7 7 7 0 700 705 7 7 7 0 700 705 7 7 7 7 0 700 705 7 7 7 7 7 0 700 705 7 7 7 7 7 0 705 7 7 7 7 7 7 7 7 0 705 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7	642 656 642 656 642 656 643 680 -0 643 681 643 685 530 645 757 645 681 645 6	Mean K. Flat K. Steep K. Astig Posterior Axial Mean K. Flat K. Steep K. Astig Total Corneal P. Mean TCPIOL. Flat TCPIOL. Steep TCPIOL. Astig Pachymetry o Thinnest	40.84D 42.36D 1.51D Curvature 4.02D 5.88D 4.16D 0.27D taneous C 5.95D 5.70D 4.20D 0.51D Swer IOL (F 10.66D 39.80D 41.53D 1.73D	63° 63° 174° 84° 84° 84° 84° 164° 74° 74° 74° Ray Traced	R R1 R2 e ² (-Q) R R1 R2 e ² (-Q) (Tangenta) R R1 R2 e ² (-Q) (Tangenta) Cantena Periph (Decation x,y)	8.26mm 7.97mm 0.19 6.64mm 6.80mm 6.80mm 0.47 6.72mm 6.45mm 0.47 40.50D 40.50D 41.01D	-0.19mm
150, 336, 39, 40, 30, 417 2, 34, 39, 41, 425 1, 57, 8, 59, 40, 8, 20, 41, 10 1, 57, 8, 59, 40, 8, 20, 41, 0 1, 57, 8, 59, 40, 8, 40, 40, 40, 40, 40, 40, 40, 40, 40, 40	20.6 41.5 40.9 40.2	20173 684 631 618 1754 681 635 67 0 1754 681 635 67 0 1754 681 643 640 210 726 681 643 640 210 726 681 643 640 210 726 681 643 640 210 726 700 705 4 3 2 10 700 705 4 3 2 70 700 705 4 3 7 7 0 700 705 7 7 7 7 0 700 705 7 7 7 7 0 700 705 7 7 7 0 700 705 7 7 7 7 0 700 705 7 7 7 7 7 0 700 705 7 7 7 7 7 0 705 7 7 7 7 7 7 7 7 0 705 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7	642 656 642 656 642 656 643 680 -0 643 681 643 685 530 645 757 645 681 645 6	Maan K. Flat K. Steep K. Astig Posterior Axial Mean K. Flat K. Steep K. Astig Posterior Instat Mean K. Flot Corneal P. Mean CFOIO. Flat CFOIO. Steep ICPIOL. Astig Pachymetry o Thinnest Central	40.84D 12.36D 1.51D Curvature 6.02D 5.88D 6.16D 0.27D taneous C 5.95D 5.70D 6.20D 0.51D www.r IOL (F 0.66D 39.80D 1.53D 1.73D 604µm 616µm	63° 63° 174° 84° 84° 84° 164° 74° 74° 74° 74° 74° 74° 74° 74° 74° 7	R R1 R2 e ² (-Q) R R1 R2 e ² (-Q) (Tangenta) R R1 R2 e ² (-Q) (Tangenta) Cantena Periph (Decation x,y)	8.26mm 7.97mm 0.19 6.64mm 6.80mm 6.50mm 0.47 6.72mm 0.47 6.45mm 0.47 40.50D 40.88D 41.01D	-0.19mm
150, 20.6 39.9 40.9 41.7 2 54, 39.9 41.8 42.5 1 7,8 39.8 40.8 40.9 41.0 1 7,8 39.8 40.8 40.9 41.0 1 40,4 42.0 40.7 40.7 40.4 2 40,4 40.7 40.7 40.7 40.4 4 05 123 40.7 40.7 40.4 4 05 123 40.7 40.7 40.4 90 4 05 123 40.7 40.7 40.4 91 4 05 123 40.7 40.7 40.7 40.4 91 4 05 123 40.7 40.7 40.7 40.4 91 4 05 123 40.7 40.7 40.7 40.7 40.7 40.7 40.7 40.7	20.5 40.5 40.0	2017 9 694 631 618 1754 681 635 67 0 1754 681 635 67 0 1754 681 643 640 210 726 681 643 640 3- N 724 70 700 705 4 3 2 10 700 705 4 3 2 10 700 705 4 3 2 10 70 705 5 10 71 70 705 10 70	642 656 642 656 642 656 643 680 -0 643 681 643 685 530 645 757 645 681 645 6	Mean K. Flat K. Steep K. Astig Posterior Axial Mean K. Flat K. Steep K. Astig Posterior Instand Mean K. Flat K. Steep K. Astig Pachymetry Central Astig Pachymetry Central Anterior Chamil	40.84D 12.36D 1.51D Convature 4.02D 5.88D 4.16D 0.27D 5.95D 5.70D 4.20D 0.51D over IOL (F 0.66D 39.80D 1.73D 604µm 616µm ser and Bio	63° 63° 174° 84° 84° 84° 164° 74° 74° 74° 74° 74° 74° 74° 74° 74° 7	R R1 R2 e ² (-Q) R R1 R2 e ² (-Q) (Tangential) R R1 R2 e ² (-Q) I) Central 4 Mid Periph 4	8.26mm 7.97mm 0.19 6.64mm 6.80mm 6.50mm 0.47 6.72mm 6.45mm 0.47 40.50D 40.50D 41.01D 0.57mm 607μm	-0.19mm
150, 93, 6, 33, 9, 40, 41, 7 2, 54, 33, 41, 8, 25 1, 7, 35, 40, 40, 42, 7 1, 7, 35, 40, 40, 42, 6 1, 7, 35, 41, 42, 5 1, 7, 35, 41, 42, 5 1, 7, 4, 5, 42, 5 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1	20.6 40.9 40.9 40.2 40.9 40.2	2017 9 694 631 618 1754 681 635 67 0 1754 681 635 67 0 1754 681 643 640 210 726 681 643 640 3- N 724 70 700 705 4 3 2 10 700 705 4 3 2 10 700 705 4 3 2 10 70 705 5 10 71 70 705 10 70	642 656 642 656 642 656 643 680 -0 643 681 643 685 530 645 757 645 681 645 6	Mean K. Flat K. Steep K. Astig Posterior Axaal Mean K. Flat K. Steep K. Astig Total Corneal P. Mean K. Steep K. Astig Total Corneal P. Mean CR/DIOL. Flat TCPIOL. Astig Pachymetry o Thinnest Central Anterior Cham WWW, N. T.	40.84D 42.36D 1.51D Curvature 6.02D 5.88D 6.16D 0.27D 5.95D 5.95D 5.70D 6.20D 5.95D 5.70D 6.20D 5.95D 5.70D 6.420D 5.70D 6.420D 7.70D 6.420D 7.70D 6.420D 7.70D 6.420D 7.70D 6.420D 7.70D 6.420D 7.70D 6.420D 7.70D 6.420D 7.70D 6.420D 7.70D 6.420D 7.70D 6.420D 7.70D 6.420D 7.70D 6.420D 7.70	63° 63° 174° 84° 84° 84° 164° 74° 74° 74° 74° 74° 74° 74° 74° 74° 7	R R1 R2 e ² (-Q) R R1 R2 e ² (-Q) R R1 R2 e ² (-Q)) Central 4 Mid d Periph Iocation x,y CCT Mean Angle	8.26mm 7.97mm 0.19 6.64mm 6.80mm 6.50mm 0.47 6.72mm 6.45mm 0.47 40.50D 41.01D 0.57mm 607µm 29.6°	-0.19mm
150, 20, 6, 29, 9, 40, 9, 41, 7, 41, 5, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,	20.6 40.9 40.9 40.2 40.9 40.2	2017 73 684 631 633 1754 681 655 67 0 1754 681 655 67 0 1754 681 655 67 0 1759 666 61 649 660 3 N 734 720 708 705 10 726 681 649 660 3 N 734 720 708 705 10 176 691 70 705 10 176 691 70 705 10 176 705	53 709 642 655 642 656 643 641 653 645 550 650 T 20 3 4 655 631 mm Arg Oµm [zadus55 6.81 mm Arg Oµm [zadus55 6.81 mm Arg Oµm [zadus55 6.91 mm 60 9 mm 50 9 mm	Mean K. Flat K. Steep K. Astig Poterior Axial Mean K. Flat K. Steep	40.84D 42.36D 1.51D Curvature 4.02D 5.88D 4.16D 0.27D taneous C 5.70D 4.20D 0.51D 5.70D 4.20D 0.51D 5.70D 4.20D 0.51D 5.70D 4.20D 4.20D 4.153D 1.73D 4.16D 4.20D 4.16D 4.20D 4.16D 4.20D 4.16D 4.20D 4.16D 4.20D 4.16D 4.20D 4.16D 4.20D 4.16D 4.20D 4.16D 4.20D 4.16D 4.20D	63° 63° 174° 84° 84° 84° 164° 74° 74° 74° 74° 74° 74° 74° 74° 74° 7	R R1 R2 e ² (-Q) R R1 R2 e ² (-Q) Tangentia) R R1 R2 e ² (-Q) 0) Central Mid Periph Iocation x.y CCTT Mean Angle Kappa Dist	8.26mm 7.97mm 0.19 6.64mm 6.80mm 6.50mm 0.47 6.72mm 0.47 6.45mm 0.47 40.50D 40.50D 41.01D 0.57mm 607µm 29.6° 0.98mm	-0.19mm
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$\begin{array}{cccccccccccccccccccccccccccccccccccc$	20.6 40.9 40.9 40.2 40.9 40.2	2017 9 664 631 633 1 754 651 655 67 0 1 754 651 655 67 0 1 759 666 61 649 660 3 671 622 67 0 1 729 666 61 649 660 3 70 728 61 649 660 3 70 728 61 649 660 4 05 120 70 706 705 4 05 120 710 716 61 3 5 0 12 10 716 61 2 10 72 70 706 705 4 0 1 0 1 0 1 0 1 2 10 71	53 709 642 65 500 1632 680 -0 523 681 533 685 330 5530 7 5 10 5 10 5 10 5 10 5 10 1 17 5 10 1 17 1 17	Maan K. Flat K. Steep K. Astig Posterior Axial Mean K. Flat K. Steep K. Astig Posterior Instand Mean K. Flat K. Steep K. Astig Teal Corneal P. Mean TCPIOL. Astig Padymetry o Thinnest Central Astig Padymetry o Thinnest Central Mean Cornel Control Control Steep CFIOL Control Cont	0.840 12.360 22.360 24.360 25.880 4.600 4.600 4.600 4.600 4.600 4.7000 4.7000 4.7	63° 63° 174° 84° 84° 84° 164° 74° 74° 74° 74° 74° 74° 74° 74° 74° 7	R R1 R2 e ² (-0) R R1 R2 e ² (-0) Tangental R R2 e ² (-0) 0) Central Mid Periph Iocation x,y CCT Mean Angle Kappa Dist ASL endo Iocation x,y	8 26mm 7.97mm 0.19 6.64mm 6.80mm 0.47 6.72mm 0.47 6.72mm 0.47 4.52mm 0.47 40.500 0.4080 0.4100 0.57mm 607µm 29.6° 0.98mm n/s 0.97mm	
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Figure 8. A/B: Pre-operative tomography exam of case two patient.

valent +2.73 \pm 1.41 D, using the LadarVision laser (Alcon, Fort Worth, TX, USA), and found 81.5% with UCVA greater than or equal to logMAR 0.2, and 44.4% greater or equal to logMAR 0. And he found no loss of corrected lines of sight². Chang et al compared hyperopia treatment using LadarVision (+ 2.17 \pm 0.93) centering on Purkinje with good final results: (logMAR): 0.22 \pm 0.17³. Chan et al. performed surgeries comparing centralization in Purkinje or Pupil, in hyperopia patients, with a mean of +1.875 D, using VISX (Johnson & Johnson, New Brunswick, New Jersey, USA) and found better results in patients centralized in Purkinje⁴.

Kermani et al also performed hyperopia treatment with + 2.57 \pm 1.56 D, using NIDEK (NIDEK, Maehama, Japan) comparing centralization in Purkinje and

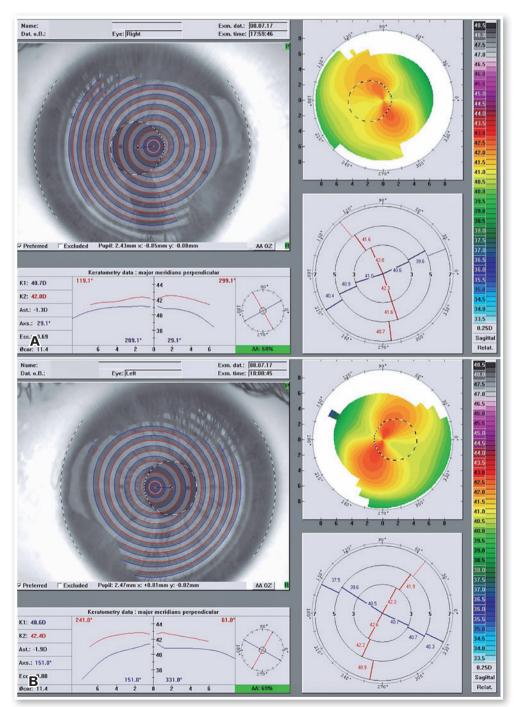


Figure 9. A/B: Topography exam of case two patient showing higher kappa angle.



🛸 WaveL	ight EX50	D Treatment R	Report				Alco
						Treatment information	
					~ ~	Method Wavefront Optimized	Status Completed
					OD	Planned by DOCTOR	Treated by DOCTOR
							Treatment date 07.08.2017 19:13:2
						Confirmed by DOCTOR	Device SN 1016-2-299
Refractive & Corr	neal details					Ablation profile	
	+5.00 D -1.25 D @ 1	5°/12.0 mm					- ES.
Pupil/Medication 6	5.0 mm / MMC						501
Pachymetry	Superior	Temporal	Central	Nasal	Inferior		72
	µm	µm	605 µm	µm	µm		
	40.66 D @ 28 ° / -0.4						
K2 / Q2 4	41.98 D @ 118 * / -0.	48					
Freatment details							
	D D @ °/	mm					41
Target 4	+0.00 D +0.00 D @ 1	5 ° / 12 mm				4.0 30 2.0 1.0 0	0 10 20 30 4.0
Correction 4	+5.00 D -1.25 D @ 1	5 ° / 12 mm					31
Target Q -			Nor	nogram \$ 001			24
Optical zone 6				ned flap 120 µm			20.
Transition zone 1	1.20 mm			ikkness 605 µm			13
Ablation zone 8	3.90 mm		Residual	stroma 401 µm			7.0
Freatment related	dinformation					max: 83.51µm	cen: 0.00µm 0.0
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(static)	0.0 °		Pa	chymetry recor	ds	Memo	
Centration X/Y -	425 µm/ -40 µm		PreOf	• µm			
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Breaks 5	5 (44 s)	21	PostOF	μm			
ort Arth, TX 76134, 1	USA) Treatment F	Report	Phone: +1	Service Hotline 949-753-1393 www.alcon.com	T	Page 1 of 4 per Printed at 24.01.2018 by user DOCT WaveLight® DOC
Secon Laboratories, Second Arth, TX 76134, I	USA) Treatment F	Report	Phone: +1	949-753-1393 www.alcon.com	Treatment information Method Wavefront Optimized	Printed at 24.01.2018 by user DOCT WaveLight® EXT Alcon Status Completed
Sont C. Freeway Fort Arth, TX 76134, 1	USA) Treatment F	Report	Phone: +1	949-753-1393	Method Wavefront Optimized Planned by DOCTOR	Printed at 24.01.2018 by user DOCT Wavelight® EXI Status Completed Treated by DOCTOR
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ort Arth, TX 76134, 1	USA) Treatment F	Report	Phone: +1	949-753-1393 www.alcon.com	Method Wavefront Optimized Planned by DOCTOR	Printed at 24.01.2018 by user DOCT Wavelight® EXI Status Completed Treated by DOCTOR
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S201 S. Freeway ord Arth, TX 76134, I WaveL Refractive & Corr Refraction	usa ight" EX501 neal details +5.25 D - 1.25 D @ 12		Report	Phone: +1	949-753-1393 www.alcon.com	Method Wavefront Optimized Planned by DOCTOR Planning date 07.08.2017 18:06:01 Confirmed by DOCTOR	Printed at 24.01.2018 by user DOCT WaveLight® EXI Status Completed Treated by DOCTOR Treatment date 07.08.2017 19:20:1
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Figure 10. A/B: Surgical planning case two, showing the decentralization of the procedure to 0.425 mm and 0.390 mm respectively.

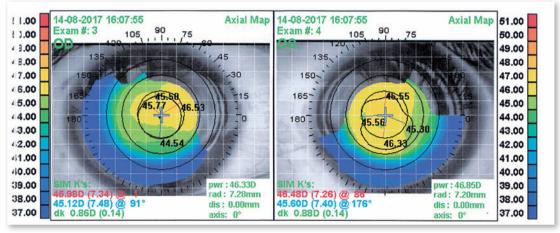


Figure 11. Final topography of case two patient.

pupil and found better results when centralized in Purkinje⁵.

De Ortueta et al. in hyperopia patients (+ 2.76 ± 0.90 D) centered on Purkinje and found a postoperative refractive result of + 0.09 ± 0.32 D, with 94% with less than 0.50 D, using Esiris laser (Schwind, Klenoistheim, Germany)⁶.

Soler et al. in hypermetropic patients (+ 2.69 ± 0.91 D) compared centralization in Purkinje and pupil using Allegretto 200 Hz (Alcon, Fort Worth, TX, USA) and found similar refractive results⁷.

Reinstein et al. in hypermetropic patients found similar results in hypermetropic patients (+ $3.85 \pm$ 0.98 D), using MEL 80 (Zeiss, Oberkochen, Germany)⁸.

Centralization issues

Most treatments guided by the total ocular aberrometry (TOA) center in the pupillary center, in this first case we imagine that the final result would be satisfactory, however, we needed a new treatment to correct the high order induced aberrations. The surgery was carried out guided by TOA and with a precise eye tracker mechanism, we were left with the hypothesis of wrong centering of the device or consequence of the Excimer laser centralization in the pupil, which may have caused coma and worsening the patient's visual quality. In retreatment, the aberrometer accurately captured the induced coma, so treatment with excimer laser should correct the induced aberration Therefore, we opted for a new treatment guided by TOA, since the device correctly captured this decentralization and proposed an appropriate treatment. It is difficult to say that this would occur in all cases of high hyperopia with an increased kappa angle, and larger studies should be carried out to verify whether it was an isolated case^{9,10}.

In the second case, with an unusual extremely high kappa angle, we were afraid to center directly on the corneal apex, so we thought to center in half of the distance between the pupil center and corneal apex, as described by some authors^{9,10}.

We show 2 cases with increased kappa angle, the second case with an unusual pattern. Even so, it is difficult, with only 2 cases to compare them, not only because of the kappa angle differences, but also different platforms, centering on different points, and different ablation profiles: one case optimized and the other wavefront-guided. In the first case, since the kappa angle was moderated, we thought that centering the treatment in the pupil center and performing a waveguided treatment should not be a problem, but we had an unusual result that required retreatment. We cannot state that pupil-centered treatments should not be performed in patients with a kappa angle similar to that of patient one, since retreatment had good results. What we suggest is to check if the ablation profile is similar to what you want, in cases of personalized treatments.

Patients with moderate to high hyperopia are more likely to have an increased kappa angle. Most authors prefer to center these cases at the corneal apex or some point between the apex and pupillary center. Some authors believe that centering in the pupillary center, in cases with a kappa angle, can lead to an increase in HOA, especially coma^{1,2,7-10}.

These two cases only brought the need for large and more detailed studies in hyperopic patients with moderate to large kappa angles to determine which centralization method should be the gold standard.

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200