Case Series: Impact of Wavefront-Guided Scleral Lenses on Visual Performance

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Introduction

Higher order aberration (HOA) correction has been demonstrated to provide improved vision correction over traditional methods; however, most of these results have been limited to laboratory conditions. Meanwhile, scleral contact lenses have become common for patients with keratoconus due to their ability to correct irregular astigmatism while improving comfort compared to a corneal gas permeable contact lens. Scleral lenses provide an ideal platform for wavefront-guided (W-G) correction due to their high stability. **In this case series, we utilize newly available ocular wavefront sensing technology to apply wavefront-guided corrections onto scleral lenses in patients with a variety of clinical conditions.** We examine patients with corneal ectasias and patients with normal vision who want to maximize visual performance for athletics or any reason.

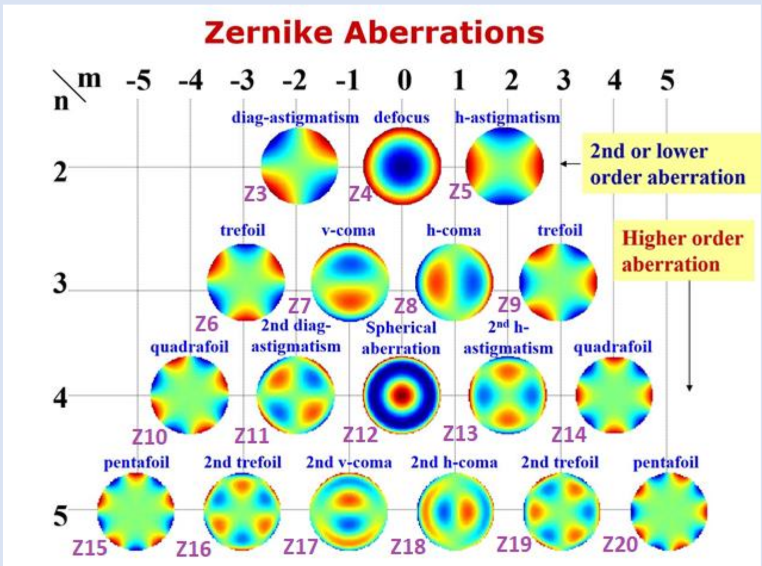

Fig 1. Individual ocular aberrations represented by Zernike polynomials.

Methods

An OVITZ™ **x**wave system was used to measure wavefront aberrations and design wavefront-guided lens profiles. These design profiles were used to create wavefront-guided scleral lenses on a Valley Contax Custom Stable™ lens. Visual performance of the wavefront-guided lens was compared to the baseline scleral lens and the patient's habitual correction. Visual performance was evaluated with visual acuity and higher order root-mean-square (RMS) in addition to contrast sensitivity (Vector Vision CSV-1000) and dynamic visual acuity (Wayne Robot Rotator) in some cases.

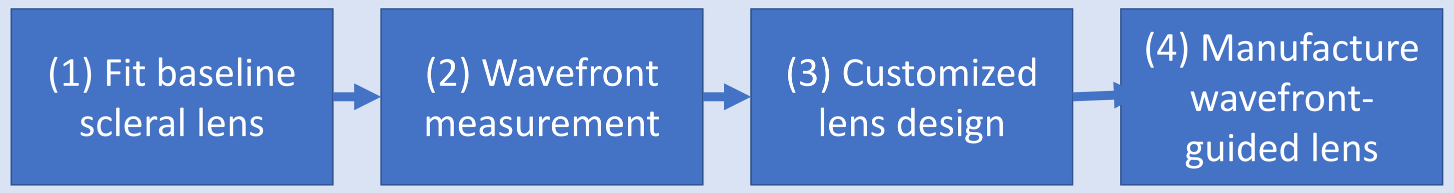

Fig 2. Step-by-step process of wavefront-guided lens creation

Technologies used: OVITZ xwave valleycontax

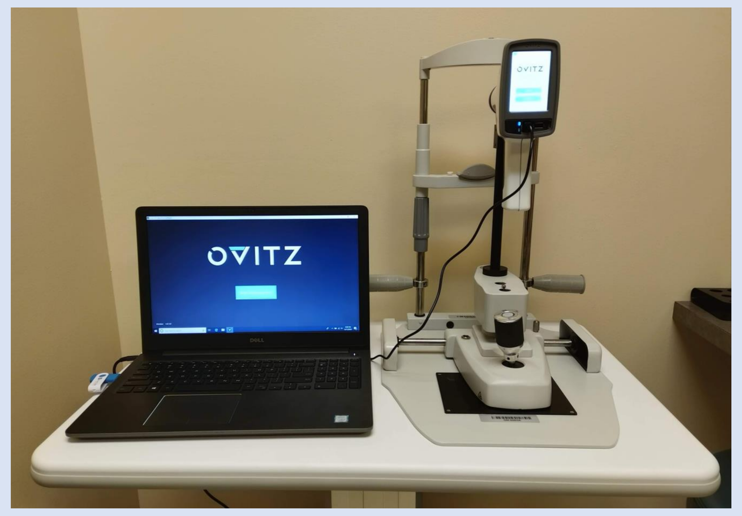

Fig 3. OVITZ xwave system used for aberrometry measurement and wavefront-guided lens design

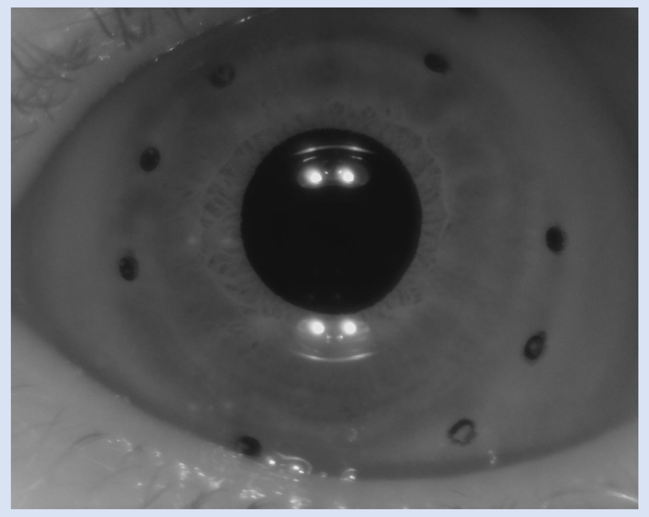

Fig 4. Baseline scleral lens with index marks used as an intermediary for fitting wavefront-guided lens.

Conclusion

Wavefront-guided scleral lenses were able to provide superior results across a variety of different clinical conditions. A keratoconus patient was able to achieve superior visual performance despite severe scarring. This will delay the need for corneal transplant and improve quality of life. A post-LASEK patient was able to achieve superior visual performance through improved correction of higher order aberrations. Finally, an amateur athlete with standard refractive error was able to achieve superior vision and better lens stability in demanding environments.

Case 1 – Advanced Keratoconus with Dense Scarring

Description

A 38 year-old white male presented with advanced keratoconus in each eye. In addition to very thin corneas (thinnest: 233 microns OD and 267 microns OS) and dense central stromal scarring, this patient has additional corneal scarring in the right eye from a projectile injury in 2016 that had no associated corneal perforation. He has keratoconjunctivitis (non-Sjogren's) and allergic conjunctivitis that are well managed with Xiidra bid and Pazeo qam. The patient was fit with scleral lenses in 2017. Over time, quality of vision declined from 20/25-2 to 20/40 likely due to central corneal scarring progression. **Wavefront-guided scleral lens were able to improve vision despite dense scarring. Although light scatter from corneal scarring is still limiting vision improvement, wavefront-guided lenses have improved vision and prolonged the need for corneal transplantation.**

Measure	Baseline Lens	W-G HOA Lens
VA OD	20/30	20/25-2
WF HOA RMS OD	1.80 µm (6.3 mm dia.)	1.19 µm (6.3 mm dia.)
VA OS	20/40+2	20/25-2
WF HOA RMS OS	2.22 µm (6.3 mm dia.)	1.53 µm (6.3 mm dia.)

Table 1. Visual performance comparison between habitual vision, baseline scleral lens, and wavefront-guided scleral lens.

Fig 5. Slit lamp images of OD eye showing keratoconus and corneal scarring.

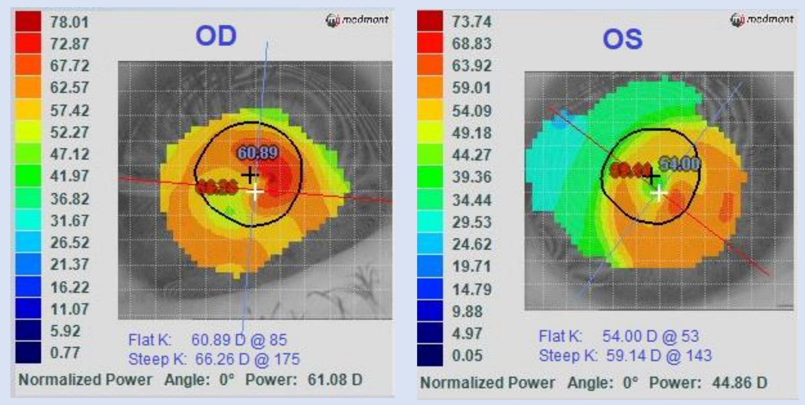

Fig 6. Corneal topography performed using Medmont E300.

Pachymetry	OD	OS
Central CT	287 um	416 um
Thinnest CT	233 um	267 um

Table 2. Anterior segment pachymetry as measured using Zeiss Cirrus 5000.

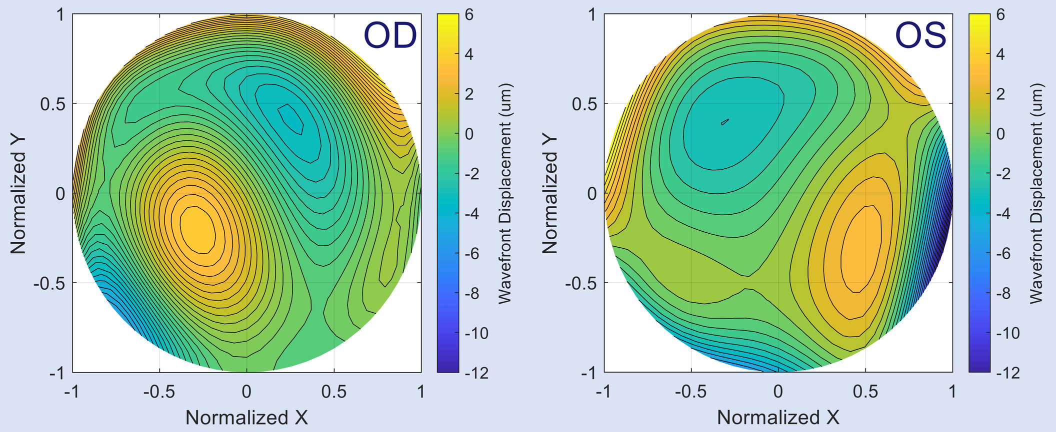

Fig 7. Wavefront aberrometry on baseline scleral lens performed using OVITZ xwave. 6.3 mm pupil diameter. Aberrometry map includes only higher order aberrations above Z6.

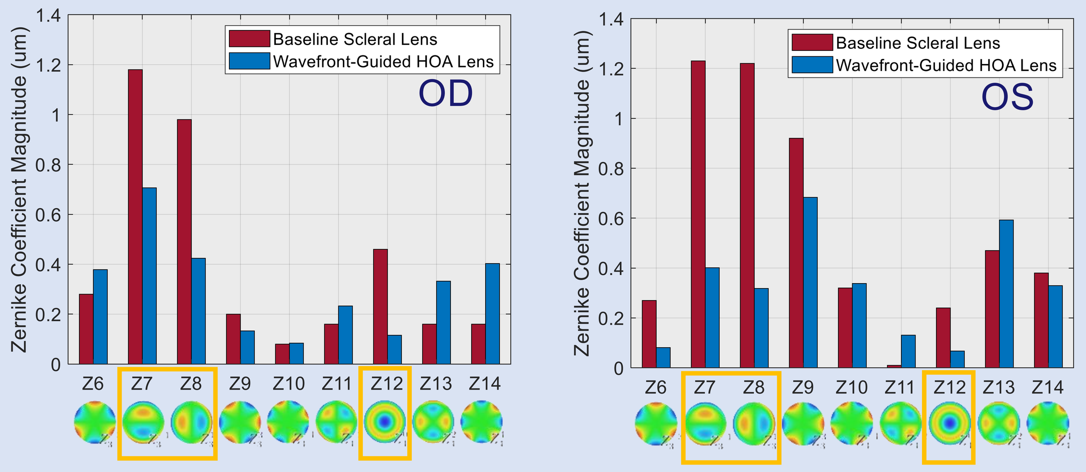

Fig 8. Comparison of individual Zernike polynomials before and after wavefront correction. Only coma (Z7+Z8) and spherical aberration (Z12) were corrected for these lenses. These are the primary aberrations seen in keratoconus patients. Aberrometry at 6.3 mm pupil diameter.

Case 2 – Post-LASEK – Athlete / Performance Vision

Description

A 30 year-old male amateur soccer player reported to the sports and performance vision clinic seeking improved visual performance. They refracted at 20/25 with soft contact lenses. With the wavefront-guided lens the patient was able to achieve 20/16 vision. The subject was evaluated using dynamic visual acuity and contrast sensitivity to estimate visual performance during sports play. **Although there was no improvement in static VA relative to the standard scleral lens, there were significant increases in dynamic VA and contrast sensitivity with the wavefront-guided lens.**

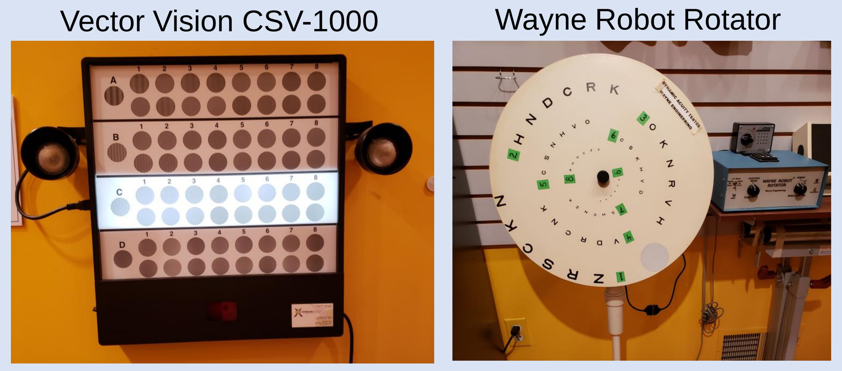

Fig 9. Contrast sensitivity and dynamic visual acuity instruments.

Measurement	Habitual (no lens)	Baseline Lens	W-G HOA Lens
VA OD	20/20-2	20/16	20/16
VA OS	20/20	20/16	20/16
VA OU	20/20	20/16	20/16
WF HOA RMS OD	*Not measured*	0.50 µm (7.4 mm dia.)	0.41 µm (7.4 mm dia.)
WF HOA RMS OS	*Not measured*	0.62 µm (7.4 mm dia.)	0.47 µm (7.4 mm dia.)
Contrast Sensitivity OU	6 / 6 / 4 / 4	6 / 8 / 6 / 4	8 / 8 / 8 / 6
Dynamic VA OU	CW 5/4 CCW 6	CW 7 CCW 7/2	CW 7/2 CCW 9

Table 3. Visual performance comparison between habitual vision, baseline scleral lens, and wavefront-guided scleral lens. Contrast sensitivity was measured with Vector Vision CSV-1000. Contrast sensitivity was measured at 3/6/12/18 cycles per degree. Dynamic visual acuity was measured utilizing a unique protocol with Wayne Robot Rotator.

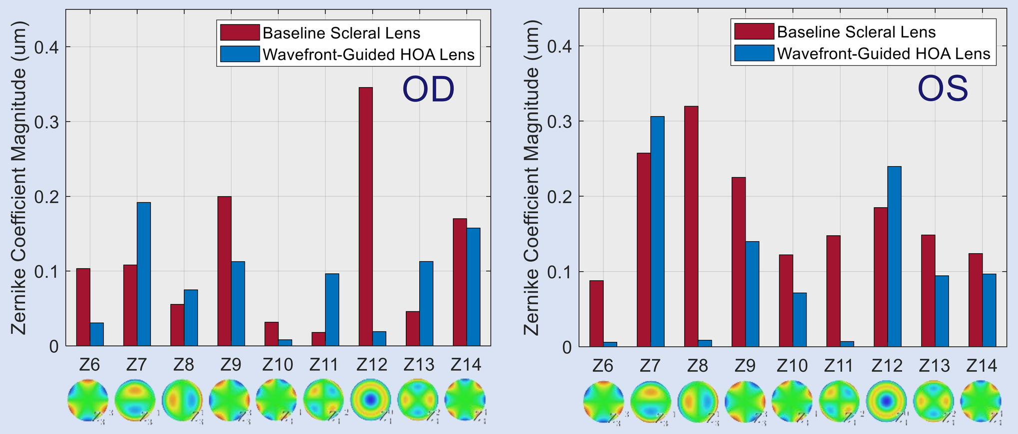

Fig 10. Comparison of individual Zernike polynomials before and after wavefront correction. Zernike aberrations Z6-Z27 we integrated into the W-G lens. Aberrometry at 7.4mm pupil diameter.

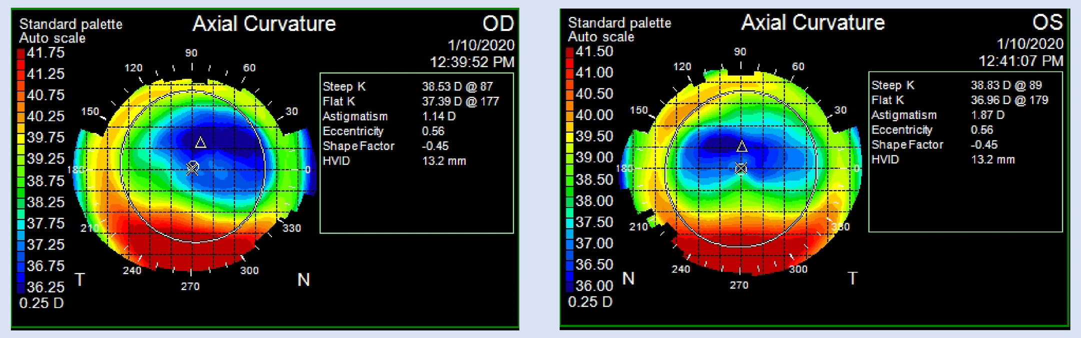

Fig 11. Corneal topography performed using Zeiss Atlas Model 9000.

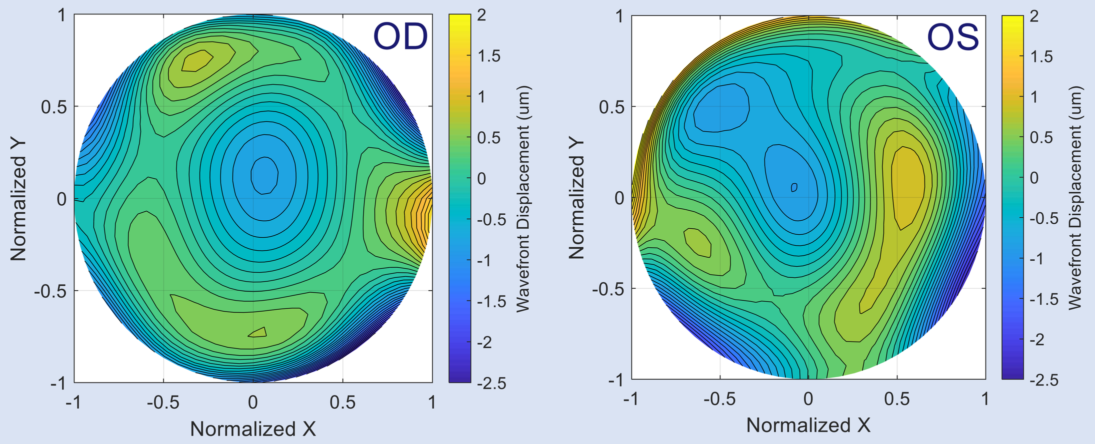

Fig 12. Wavefront aberrometry on baseline scleral lens performed using OVITZ xwave. 7.4 mm pupil diameter. Aberrometry map includes only higher order aberrations above Z6.

Case 3 – High Cylinder – Athlete / Performance Vision

Description

A 47 year-old male off-road motorcycle racer and outdoorsman reported to the sports and performance vision clinic seeking improved visual performance free of spectacle correction. He had previously worn both GP and soft toric contact lenses with marginal success. GP lenses were often uncomfortable due to dusty off-road racing conditions. Toric SCL's, while a more appropriate correction for his activities, provided unstable visual performance. His spectacle correction (OD: -1.00-4.50x108 OS: -0.75-4.25x82) was excellent (20/16 OU), however, spectacles are also contraindicated for off-road motorcycle racing. In consideration of demanding environmental challenges, scleral CL's were proposed and fitted, providing acceptable comfort and visual performance. HOA-correcting scleral CL's provide improved visual performance; VA, CS and DVA. **He stated that he had never seen this well before and is ecstatic with the lenses.**

Measurement	Habitual Lens (specs)	Baseline Lens	W-G HOA Lens
VA OD	20/16-	20/16+2	20/12.5+2
VA OS	20/16-	20/16	20/12.5+2
VA OU	20/16	20/12.5-	20/10-2
WF HOA RMS OD	*Not measured*	0.23 µm (6.3 mm dia.)	0.23 µm (6.3 mm dia.)
WF HOA RMS OS	*Not measured*	0.27 µm (6.3 mm dia.)	0.19 µm (6.3 mm dia.)
Contrast Sensitivity OU	6 / 5 / 4 / 4	6 / 7 / 7 / 6	7 / 8 / 7 / 8
Dynamic VA OU	CW 4 CCW 7	CW 4/3 CCW 6	CW 6 CCW 8/4

Table 4. Visual performance comparison between habitual vision, baseline scleral lens, and wavefront-guided scleral lens.

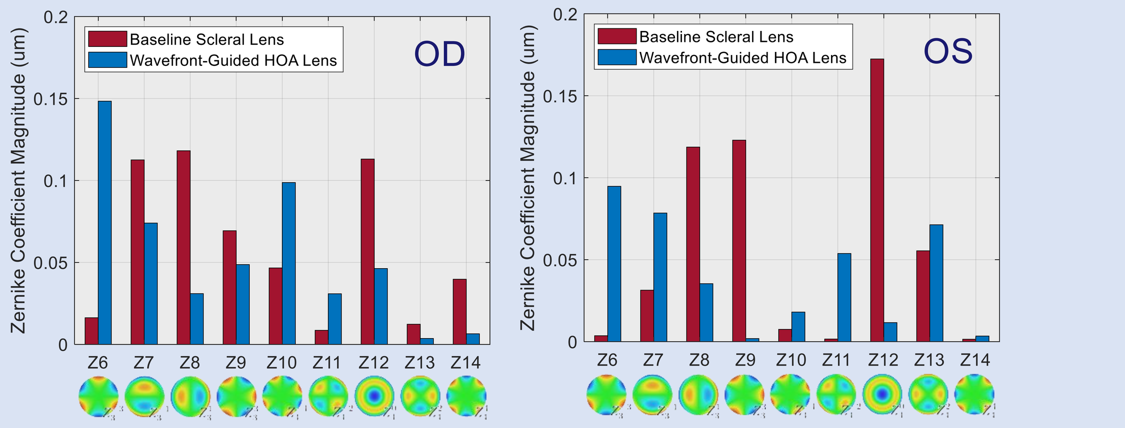

Fig 13. Comparison of individual Zernike polynomials before and after wavefront correction. Zernike aberrations Z6-Z20 we integrated into the W-G lens. Aberrometry at 6.3mm pupil diameter.

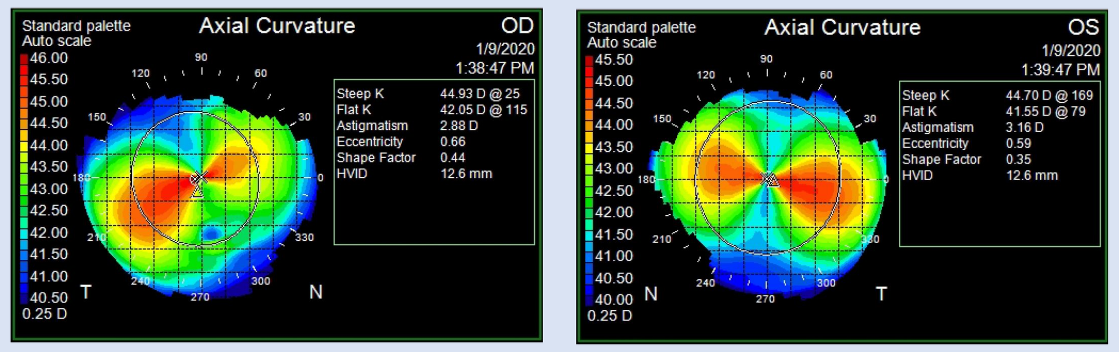

Fig 14. Corneal topography performed using Zeiss Atlas Model 9000.

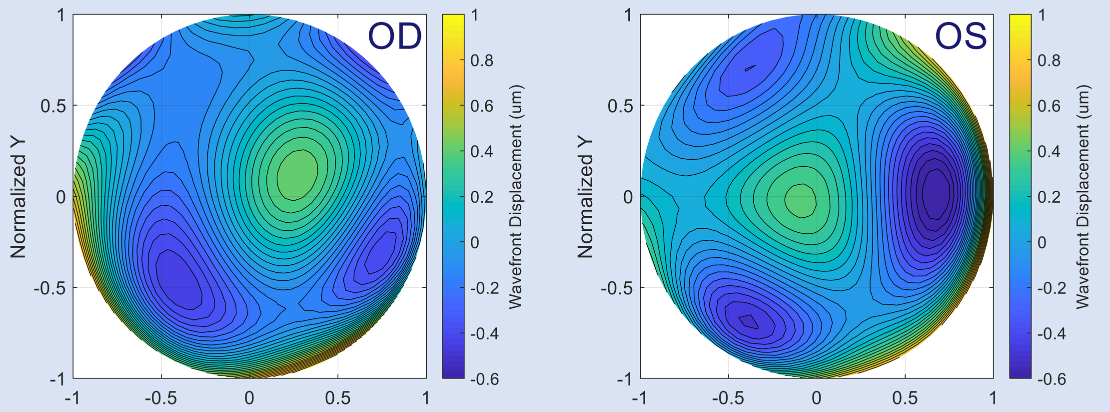

Fig 15. Wavefront aberrometry on baseline scleral lens performed using OVITZ xwave. 6.3 mm pupil diameter. Aberrometry map includes only higher order aberrations above Z6.