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

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Introduction

Higher order aberration 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 standard for patients with keratoconus due to their ability to correct irregular astigmatism while improving comfort compared to a corneal gas permeable contact lens. **In this case series, however, commercially available technology is utilized to apply wavefront-guided corrections onto scleral lenses for competitive athletes.** Scleral lenses provide an ideal platform for wavefront-guided correction due to their high stability. We demonstrate that these lenses can provide improved static and dynamic visual acuity, as well as contrast sensitivity, and that this enhanced visual performance helps athletes looking to maximize their sports performance.

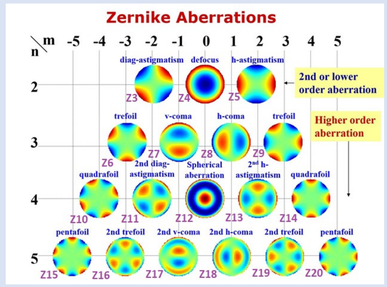

Fig 1. *Individual ocular aberrations represented by Zernike polynomials.*

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 was evaluated with visual acuity and higher order root-mean square (RMS) in addition to contrast sensitivity (Vector Vision CSV-1000, Fig. 5) and dynamic visual acuity (Wayne Robot Rotator, Fig. 6). Subjects were asked to rate their experience with the lenses and compare performance vs. prior visual correction.

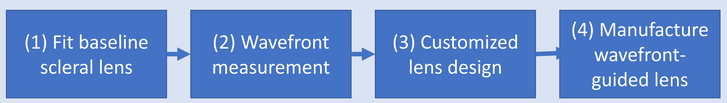

Fig 2. *Step-by-step process of wavefront-guided lens creation*

Technologies used: OVITZ xwave valleycontax

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

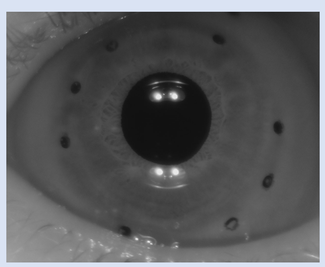

Fig 4. *Baseline scleral lens with index marks used as an intermediary for fitting wavefront-guided lens.*

Conclusion

Wavefront-guided scleral lenses provided athletes with superior visual performance and improved their sports performance. All subjects achieved improved static and dynamic visual acuity as well as improved contrast sensitivity. Both static VA and contrast sensitivity are foundational visual skills and are considered to be critical for superior complex visual functioning, such as dynamic visual acuity. This improved visual performance is thought to be achieved chiefly through the correction of higher order aberrations. Finally, all athletes reported improved athletic performance, noting superior visual function as the key to this improvement.

Case 1 – Competitive Dynamic Shooter

Description

A 40 year-old competitor in Steel Challenge, a speed shooting competition in which competitors are scored solely by the time it takes them to complete several stages (the winner logs the lowest overall time). He had previously worn soft toric lenses and although he achieved 20/15 VA though these lenses, he was distracted by visual instability and dryness. After he was refitted with wavefront-guided scleral lenses, he reported improved visual performance, including VA of 20/10^{-2} OU, less dryness and improved scores in his competition. He believes this mode of correction with aberration control is the reason for his better scores.

Measurement	Habitual (toric SCL's)	Baseline Lens	W-G HOA Lens
VA OD	20/15-2	20/20+2	20/12.5+2
VA OS	20/15-2	20/30	20/12.5+2
VA OU	20/15	20/12.5-	20/10-2
WF HOA RMS OD	0.36 µm (6.3 mm dia. & no lens)	0.21 µm (6.3 mm dia.)	0.16 µm (6.3 mm dia.)
WF HOA RMS OS	0.24 µm (5.3 mm dia. & no lens)	0.18 µm (6.3 mm dia.)	0.15 µm (6.3 mm dia.)
Contrast Sensitivity OU	6 / 5 / 5 / 5	6 / 5 / 5 / 4	7 / 8 / 8 / 7
Dynamic VA OU	CW 5 CCW 6	CW 5 CCW 6	CW 7 CCW 8

Table 1. *Visual performance comparison between habitual vision, baseline scleral lens and wavefront-guided scleral lens. Contrast sensitivity was measured with VectorVision 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 5. *Contrast sensitivity measured with VectorVision CSV-1000*

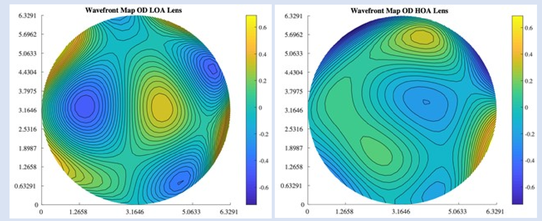

Fig 7. *Wavefront aberrometry maps on baseline & HOA scleral lenses performed using OVITZ **x**wave. 6.3mm pupil diameter. Includes only higher order aberrations above Z6.*

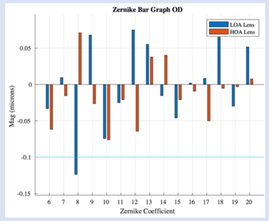

Fig 8. *Comparison of individual Zernike polynomials before and after wavefront correction. Zernike aberrations Z6-Z27 were integrated into the W-G lens. Aberrometry at 6.3mm pupil dia.*

Case 2 – BMX / MMA Fighter

Description

A 43 year-old former professional BMX (bicycle motocross) rider, current MMA fighter and performance gym owner had LASIK performed in 2016. The results left him with minor refractive error in both eyes; OD +0.25-0.75x55, OS -0.25-0.50x130. His surgeon recommended against re-treatment leaving him unhappy and feeling "imbalanced". He was referred for possible SCL fitting and elected to be fitting with HOA correcting sclerals after learning of their potential benefits. He reports his experience with wavefront-guided scleral lenses to be 'life altering' and is eager to resurrect his fighting career. He credits the lenses not only with markedly improved visual performance, but also improved balance and physical presence, critical in MMA and BMX.

Measurement	Habitual (no lens)	Baseline Lens	W-G HOA Lens
VA OD	20/25-2	20/20-2	20/15
VA OS	20/20-2	20/20-2	20/15
VA OU	20/20-	20/20	20/15+2
WF HOA RMS OD	0.42 µm (6.3 mm dia.)	0.32 µm (6.3 mm dia.)	0.20 µm (6.3 mm dia.)
WF HOA RMS OS	0.64 µm (6.3 mm dia.)	0.62 µm (6.3 mm dia.)	0.47 µm (6.3 mm dia.)
Contrast Sensitivity OU	4 / 5 / 4 / 3	5 / 6 / 6 / 4	6 / 7 / 7 / 6
Dynamic VA OU	CW 6 CCW 7	CW 6 CCW 7/2	CW 8 CCW 9

Table 2. *Visual performance comparison between habitual vision, baseline scleral lens and wavefront-guided scleral lens. Contrast sensitivity was measured with VectorVision 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.*

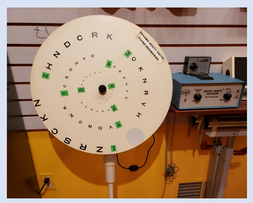

Fig 6. *Dynamic visual acuity measured with Wayne Robot Rotator. instruments.*

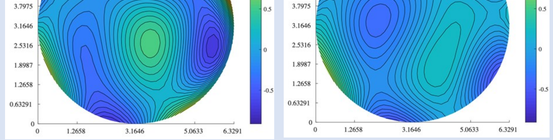

Fig 9. *Wavefront aberrometry maps on baseline & HOA scleral lenses performed using OVITZ **x**wave. 6.3mm pupil diameter (includes only higher order aberrations above Z6).*

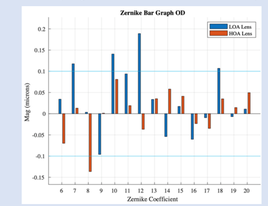

Fig 10. *Comparison of individual Zernike polynomials before and after wavefront correction. Zernike aberrations Z6-Z27 were integrated into the W-G lens. Aberrometry at 6.3mm pupil dia.*

Case 3 – Motocross / Mountain Bike Racer

Description

A 63 year-old amateur motocross and mountain bike racer and habitual soft toric contact lens wearer presented to the clinic desiring improved visual performance. Additionally, this subject was previously diagnosed with keratoconus and noted dryness and variable vision with his SCL's as well as poor vision under dim light conditions. In consideration of demanding environmental challenges and the poor performance of his habitual SCL's, wavefront-guided scleral CL's were proposed and fitted, which provided acceptable comfort and exceptional visual performance. **The subject had significant increases in dynamic tasks associated with his sports and feels that he had never seen this well before.** He is ecstatic with the performance, comfort and lack of dryness with the lenses.

Measurement	Habitual (toric SCL's)	Baseline Lens	W-G HOA Lens
VA OD	20/15-2	20/20+2	20/15+2
VA OS	20/20+2	20/20	20/15
VA OU	20/15	20/20+2	20/12.5-2
WF HOA RMS OD	0.56 µm (5.3 mm dia. & no lens)	0.27 µm (5.3 mm dia.)	0.26 µm (5.3 mm dia.)
WF HOA RMS OS	1.01 µm (5.3 mm dia. & no lens)	0.36 µm (5.3 mm dia.)	0.22 µm (5.3 mm dia.)
Contrast Sensitivity OU	4 / 5 / 4 / 2	5 / 5 / 6 / 4	7/ 7 / 6 / 5
Dynamic VA OU	CW 7 CCW 8	CW 7 CCW 8	CW 8 CCW 9

Table 3. *Visual performance comparison between habitual vision, baseline scleral lens and wavefront-guided scleral lens. Contrast sensitivity was measured with VectorVision 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.*

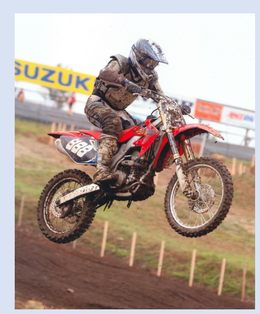

Fig 11. *Wavefront aberrometry on baseline scleral & HOA lenses performed using OVITZ **x**wave. 5.3mm pupil diameter. Aberrometry map includes only higher order aberrations above Z6.*

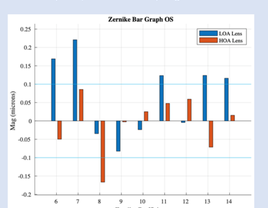

Fig 12. *Comparison of individual Zernike polynomials before and after wavefront correction. Zernike aberrations Z6-Z20 were integrated into the W-G lens. Aberrometry at 6.3mm pupil dia.*