

A Case Series: Custom Wavefront Guided Scleral Lenses for Severe Corneal Irregularities

Aaron Wolf, OD, FAAO, FSLs, FIAOMC; Sheila Morrison, OD, MSc, FAAO, FSLs, FCCSO; Alex Bennett, OD, FAAO



Introduction and Background

Scleral lenses have become a primary non-surgical option for managing complex corneal conditions such as keratoconus, pellucid marginal degeneration, and post-LASIK ectasia. However, for some patients, achieving standard visual acuity does not always guarantee clear or satisfying vision. We are in a new era of customized scleral contact lenses, driven by advanced technologies like corneo-scleral mapping and wavefront-guided optics. These data-driven approaches allow lenses to improve both comfort and visual outcomes for patients with challenging visual needs.

Case Description

Three patients with complex corneal irregularities and persistent visual complaints despite conventional scleral lenses were evaluated. Comprehensive ocular assessments included refraction, corneo-scleral profilometry, and aberrometry. All lenses fitted were freeform design with HOA correction based on the patient's ocular shape and wavefront data. Fitting assessments included fluorescein evaluation, Optical Coherence Tomography (OCT), and stability analysis. Outcomes were evaluated by best-corrected visual acuity (BCVA), HOA reduction, subjective quality-of-vision questionnaires, and comfort.

Conclusions

All patients experienced substantial improvement in visual performance. BCVA improved in all patients. Total Root Mean Square (RMS) HOA values decreased significantly in all cases, particularly in coma and trefoil. Subjective reports showed reductions in ghosting and fluctuating blur, with enhanced contrast sensitivity and overall satisfaction. Lens fit was stable in all eyes, with no adverse events during the follow-up period. These cases illustrate that profilometry-guided freeform, HOA-corrected scleral lenses provide a reliable solution for patients whose needs are unmet by traditional lens designs.

Case 1 | Keratoconus

25-year-old female; bilateral keratoconus post corneal crosslinking. Despite the procedure's success in stabilizing the corneas, she continued to experience severe Higher-Order Aberrations (HOA) resulting in poor visual quality.

A primary challenge was the low scleral toricity of only 90µm at a 15mm chord (Figure 1), insufficient to provide rotational stability in conventional scleral lenses required for consistent HOA correction.

Profilometry-driven freeform lenses enabled precise alignment and rotational stability (Figure 3). Vision improved to 20/25 in the right eye (OD) and 20/20 left eye (OS), with a remarkable reduction in HOA RMS of 86% OD and 88% OS (Figure 2).

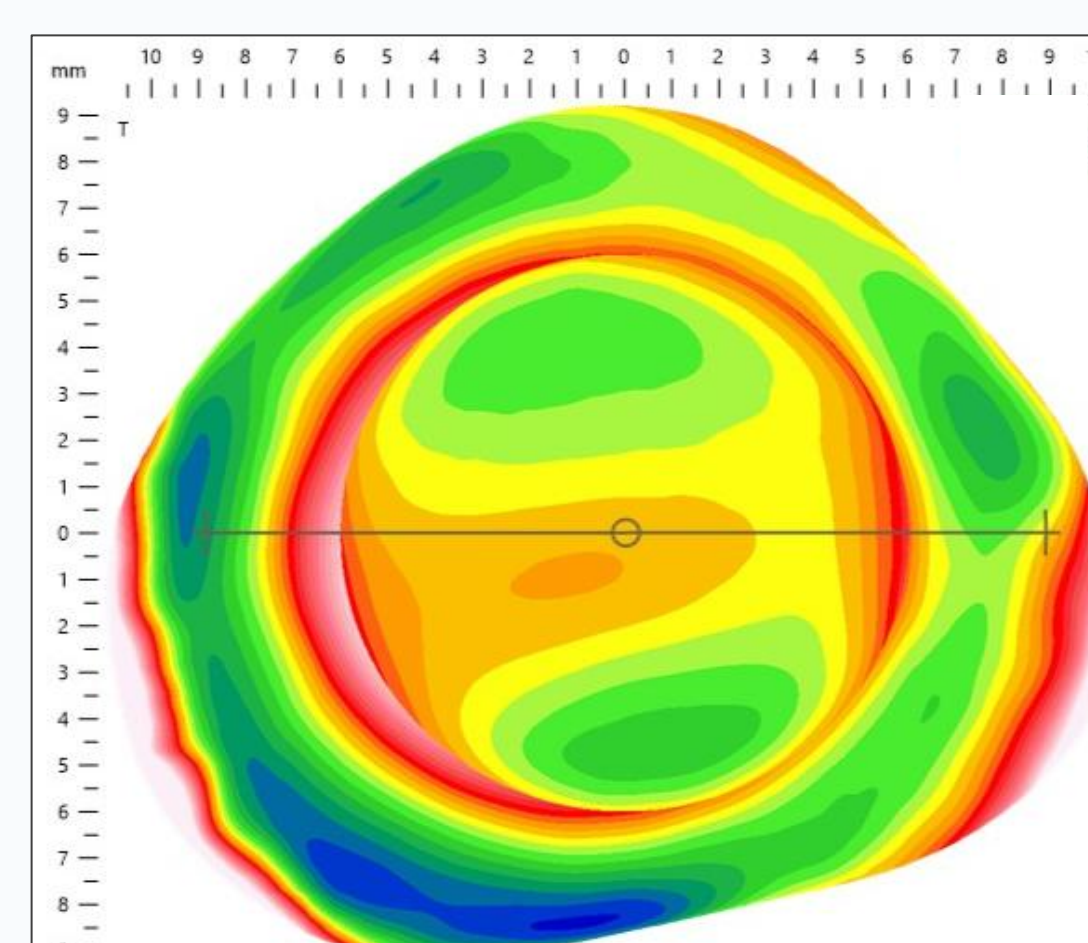


Figure 1 Bisphere Elevation map (OD).

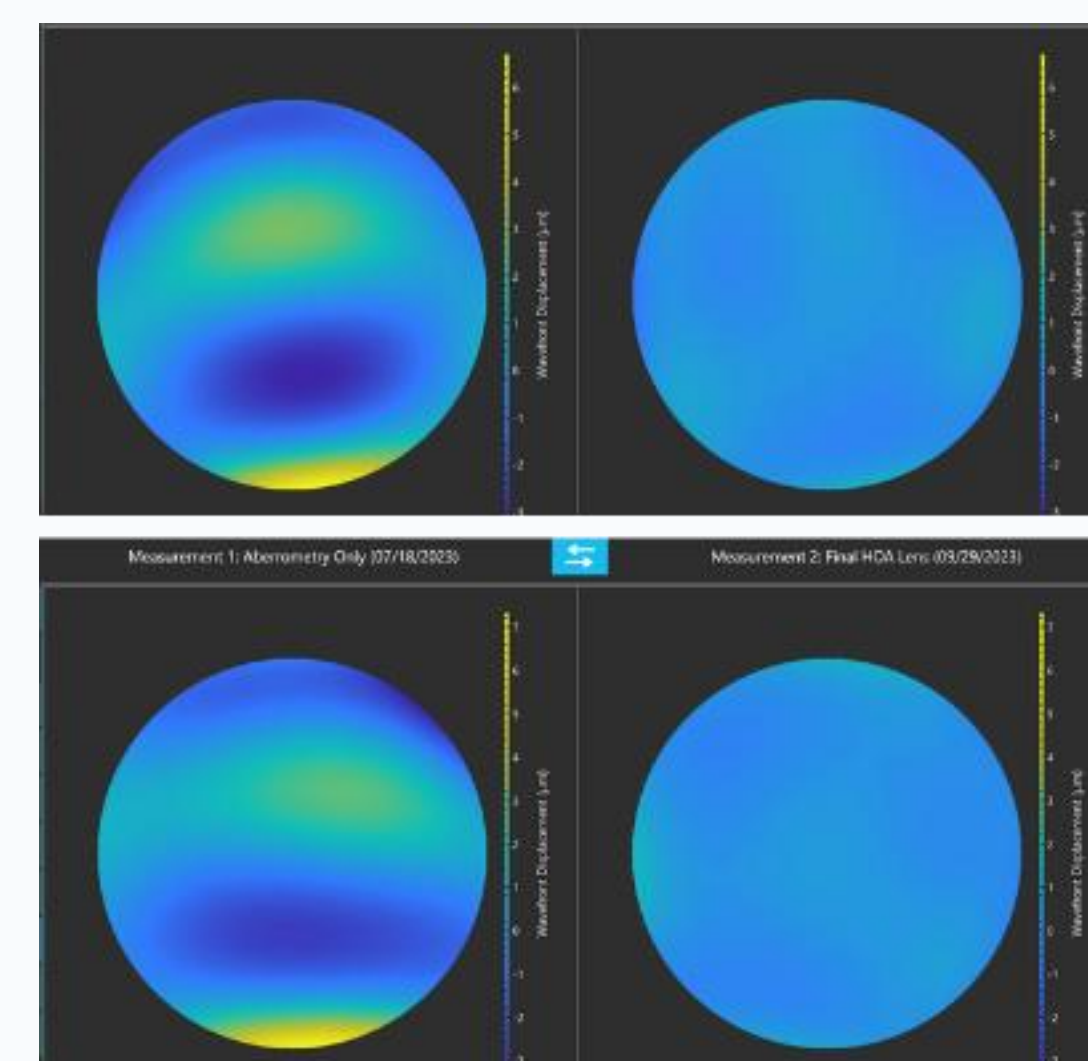


Figure 2 Wavefront maps, Baseline lens to Final HOA lens (OD/OS).

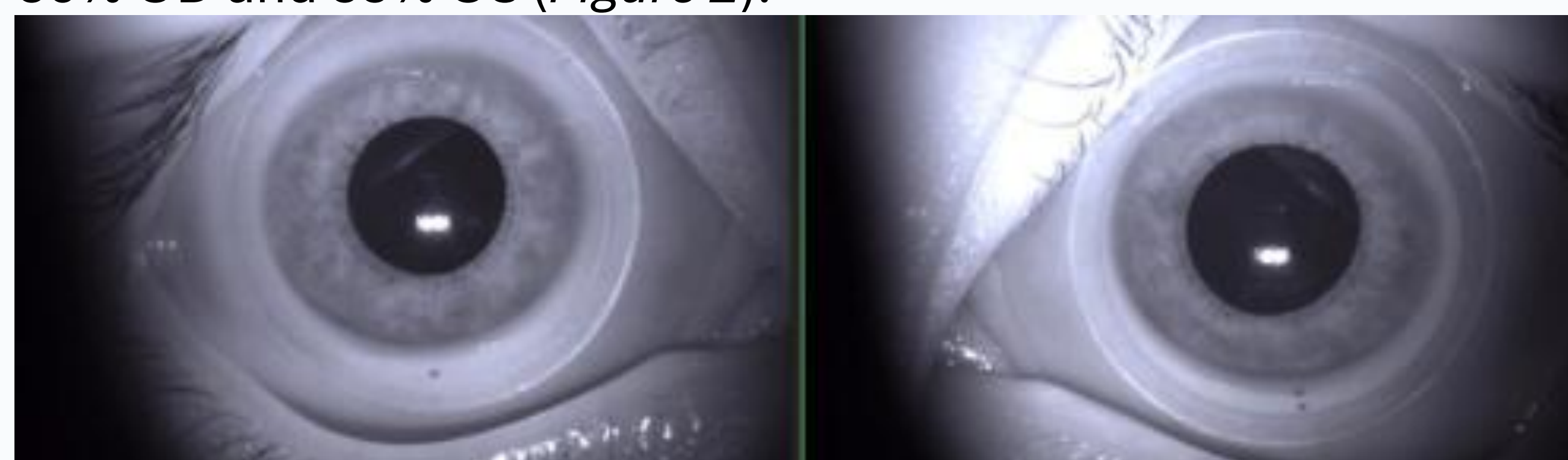


Figure 3 Infrared photos of HOA freeform lenses demonstrating good alignment and centration on both eyes.

Case 2 | Ehlers-Danlos Syndrome, post-PRK+CXL

24-year-old female with keratoconus, Ehlers-Danlos syndrome, and post wavefront PRK with concurrent corneal crosslinking. She presented with irregular, ectatic corneas, reduced acuity, and suffered from monocular diplopia and ghosting.

Corneo-scleral profilometry revealed irregular corneal astigmatism and 'against-the-rule' scleral toricity (Figure 4), guiding a freeform lens design optimized for centration and rotational stability (Figure 5). Wavefront aberrometry was used to address elevated HOAs. Following lens optimization and neuroadaptation, visual acuity improved to 20/25 OD and 20/20 OS, with a significant reduction in diplopia, ghosting, and overall HOAs (Figure 6).

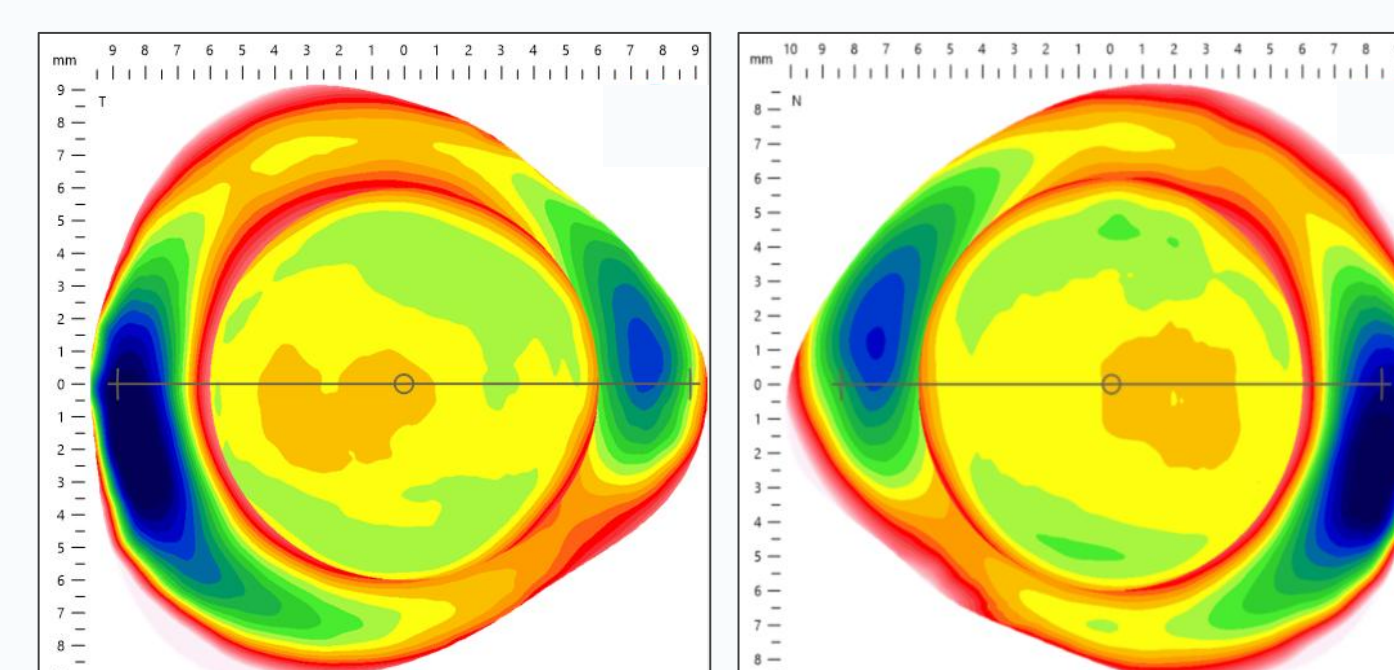


Figure 4 ESP Bisphere Elevation maps (OD/OS).

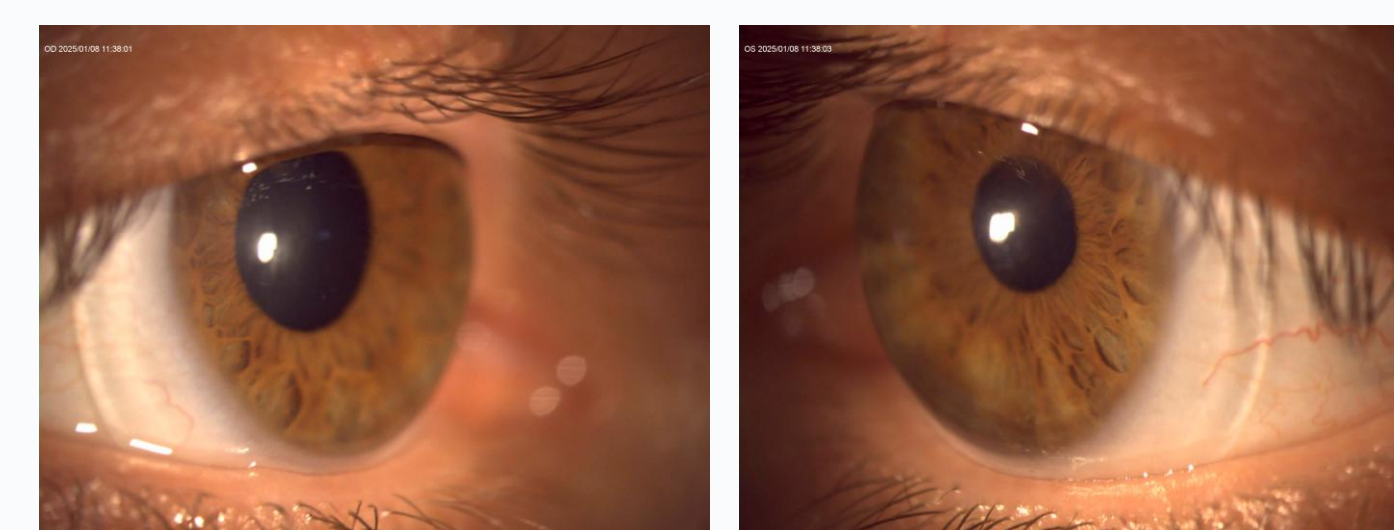


Figure 5 ESP Bisphere Elevation maps (OD/OS).

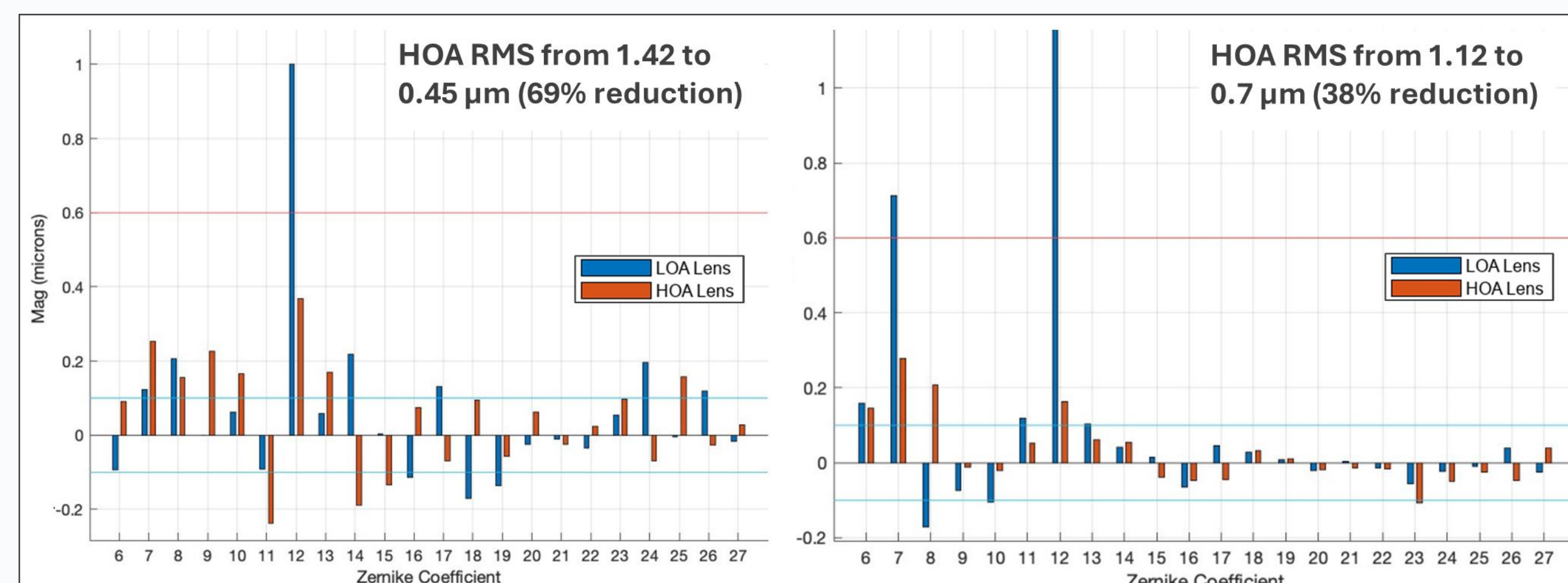


Figure 6 Comparison of individual Zernike polynomials, Baseline scleral lens to final HOA lens (OD/OS).

Case 3 | Post-LASIK Ectasia

52-year-old female with post-LASIK ectasia OD following monovision refractive surgery. She presented with progressive visual deterioration, post-LASIK ectasia, and reduced best-corrected visual acuity following prior surgical enhancement.

Corneo-scleral profilometry revealed significant corneal and scleral asymmetry (Figure 7), guiding a customized freeform scleral lens optimized for stability. The baseline freeform lens with a series of alignment markings (Figure 8) was fitted and total eye aberrometry measured. With the final HOA-corrected lens, vertical coma (Z7), the most severe aberration (Figure 9), was reduced to a subclinical value, improving VA to 20/20 and reducing HOA RMS by 57% with no visual distortion or diplopia.

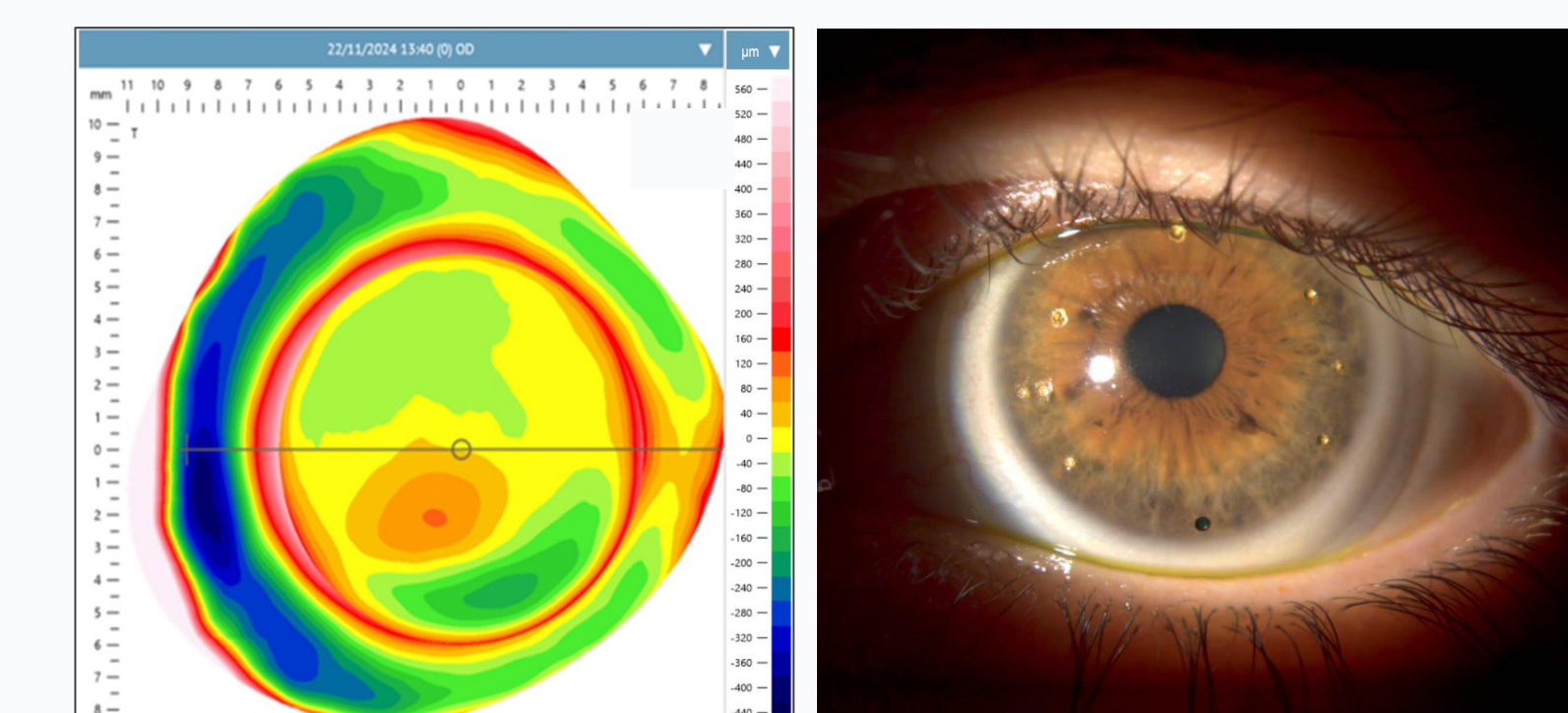


Figure 7 Bisphere elevation map. Figure 8 Baseline freeform lens with markings for HOA measurement.

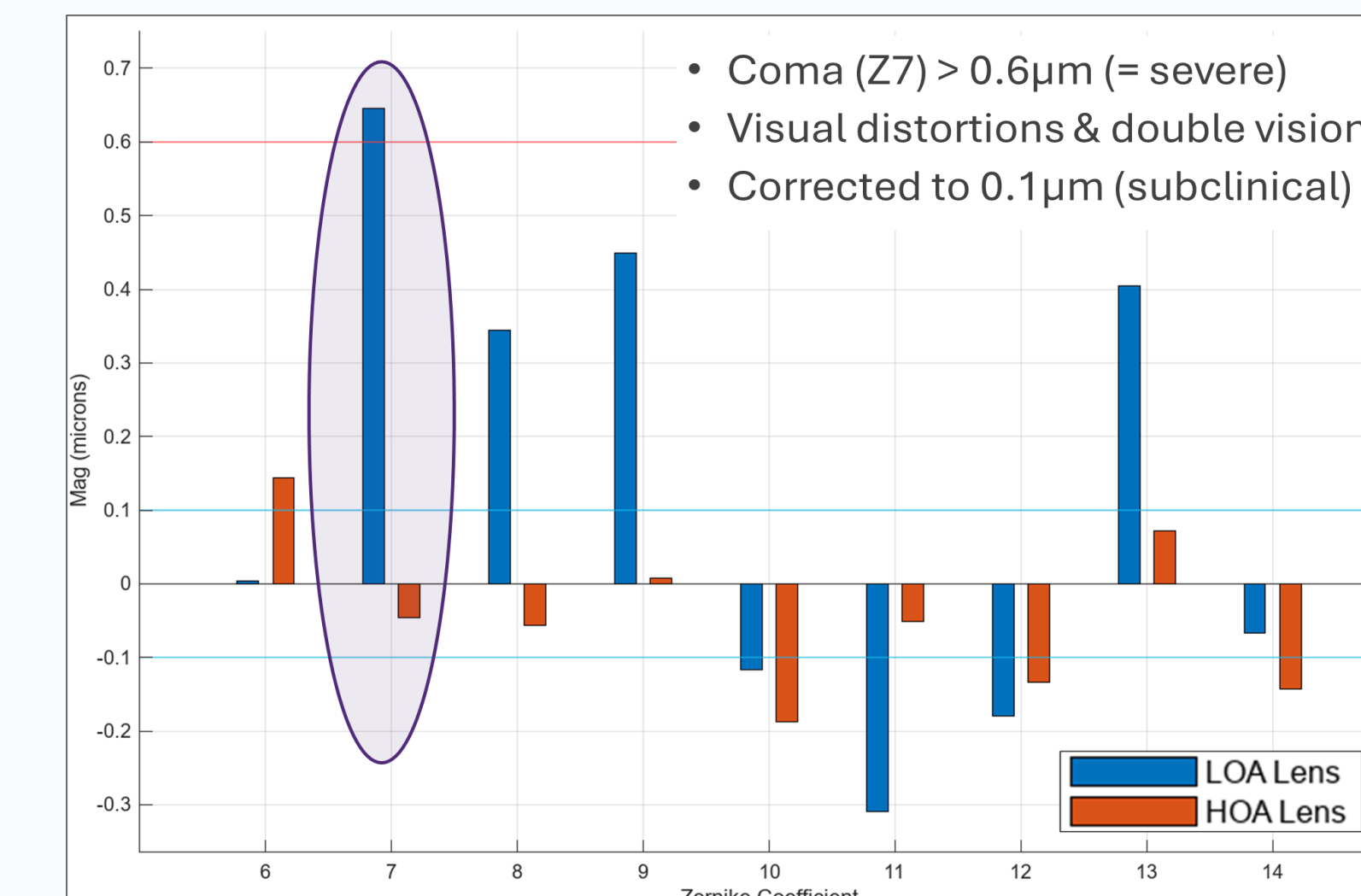


Figure 9 Comparison of individual Zernike polynomials, Baseline scleral lens to final HOA lens (OD).

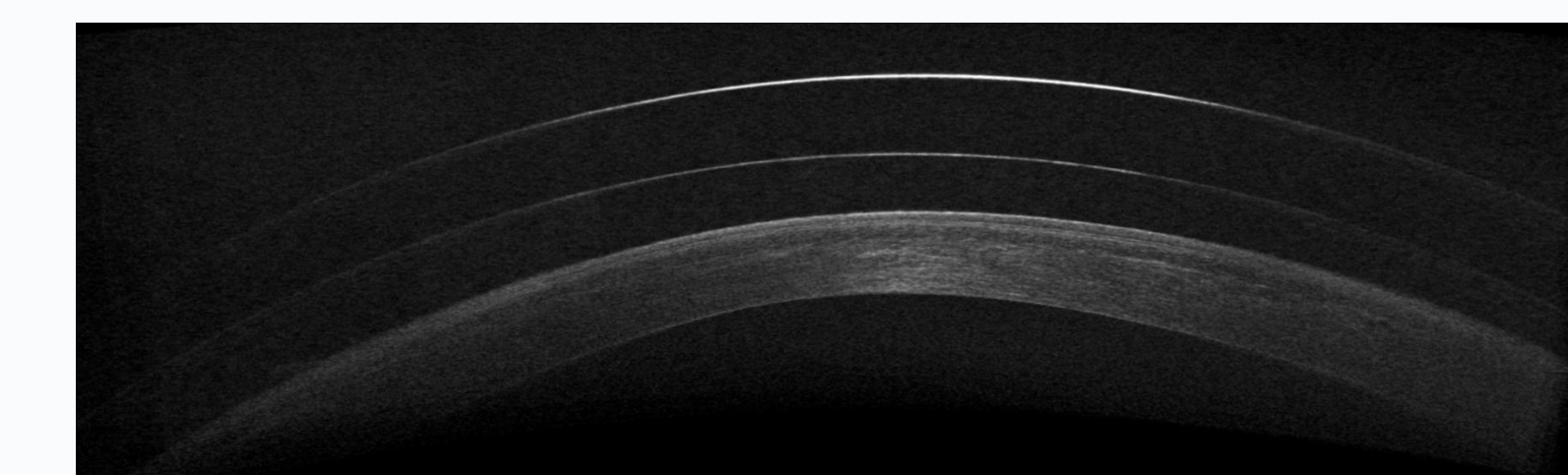


Figure 10 Cross-sectional OCT image of the HOA freeform lens (OD).