Aberration control with standard rigid gas permeable contact lenses

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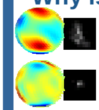
1 Background & Purpose

Goal : To measure on-eye aberrations of standard rigid gas permeable contact lenses

1. To measure the capability of standard RGP lenses to correct aberrations
2. To evaluate the possibilities of aberrometry as a new tool to assist the contact lens fitting

Why is it interesting?



Aberrations degrade retinal image quality. Some methods for correcting aberrations have been proposed recently : adaptive optics[4,5], phase plates[6], custom CLs[7], customized ablations[8,9]

RGP lenses are expected to correct corneal irregularities[11], and thus improve optical quality[14].

Background

- Psychophysical experiments have shown that RGP contact lenses can improve visual performance[10].
- Computer simulations try to understand contact lens fitting and tear lens optical properties[12,20].
- Flexure of RGP lenses is a relevant factor[13,18].

- RGP CL has been proposed to control myopia[19].

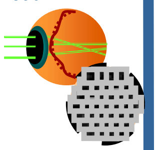
2 Methods

Four different aberration measurements:

Total and corneal (anterior), with and without contact lens

Total Aberrations: Laser Ray Tracing

A scanning beam samples the pupil. Centroids of retinal spots are used to calculate the wavefront[2,16,17]. Developed at the Inst. of Optics, Madrid.



Corneal Aberrations: Videokeratography

From elevation maps obtained with a commercial Videokeratographer (Atlas Humphrey, Zeiss) and our own computer algorithms we estimate corneal wave aberrations[1,3,15] (referred to anterior surface aberrations when the lens is on).

Subjects and lenses

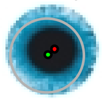
4 eyes from 4 subjects, long term and satisfied RGP contact lens wearers with their own lenses

Sph. error: -4.5 D to -8 D, Ages: 18 to 33

No ocular condition except for myopia

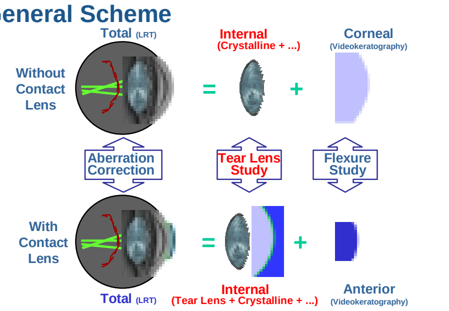
Additional measurements: Autorefractometry, keratometry & optical biometry.

Pupil Monitoring



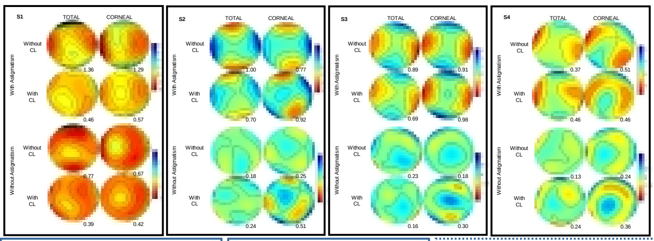
Pupil diameter: 5 mm
Measures done with stabilized lens and tear. Careful contact lens and pupil monitorization.
LRT Measures: pupil dilation by tropicamide 1%.

General Scheme



3 Results

3.1 Wave Aberrations with and without CL

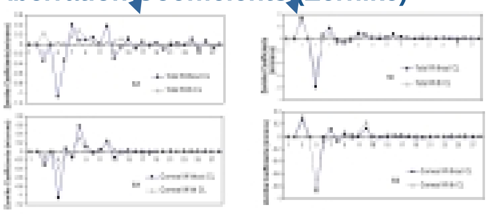


S1: High correction: high corneal aberrations and low flexure (conformity)

S2 & S3: Low correction: corneal aberrations but high flexure (conformity)

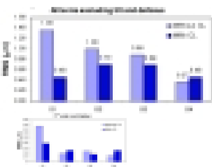
S4: No correction: corneal aberrations partially compensating internal optics

3.2 Aberration Coefficients (Zernike)



Each aberration term can be numerically tracked for every subject and every optical element (anterior surface of the lens, tear lens, cornea, internal optics (crystalline lens))

3.3 Aberration correction with RGP CLs

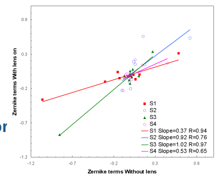


Best case: S1
1.36 → 0.46 µm (RMS no tilt & defocus)
0.77 → 0.39 µm (RMS no tilt & def & astigmatism)

Worst case: S4
No correction of total aberrations (minor increase). Slight correction of corneal aberrations.

3.3 Effects of flexure

The amount of corneal aberration correction and the degree of flexure (conformity of the lens to the cornea) can be assessed by correlating corneal Zernike coefficients to the on-eye RGP lens anterior surface coefficients. Slopes and R close to 1 are indicative of low correction and high flexure.

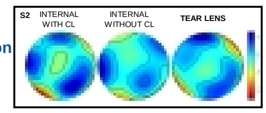


3.4 What happens to spherical aberration?

While there is important intersubject variability in corneal and internal spherical aberration, we found similar spherical aberration values for all anterior lens surfaces (as they all are spherical lenses).
Total spherical aberration with the lens is close to zero, suggesting some compensatory effect by the tear lens.

3.5 Tear lens aberration map

While this measurement is noisy and indirect (estimated as the difference of internal aberration maps) we found very systematically negative spherical aberration values.



An alternative to fluorescein analysis?

4 Conclusions

1. Aberrometry is a useful tool to understand contact lens fitting.
2. RGP lenses can reduce greatly the amount of aberrations, particularly in eyes with large corneal aberrations.
3. The control of flexure and knowledge of the internal optics can help to improve contact lens optical performance.

5 References

1. - Barbero S, Marcos S, Merayo-Lloves J, and Moreno-Barriuso E. Validation of the estimation of corneal aberrations from videokeratography In keratoconus. Journal of Refractive Surgery 2002;18:263-270.
2. - Moreno-Barriuso E, Marcos S, Navarro R, and Burns SA. Comparing Laser Ray Tracing, Spatially Resolved Refractometer and Hartmann-Shack sensor to measure the ocular wavefront aberration. Optom & Vis Sci 2001;78:152 - 156.
3. - Barbero S, Marcos S, and Merayo-Lloves JM. Exploring total and corneal aberrations in an unilateral aphakic subject. Journal of Cataract and Refractive Surgery. In press 2002;
4. - Fernandez EJ, Iglesias I, and Artal P. Closed-loop adaptive optics in the human eye. Optics Letters 2001;26:746-748.
5. - Hofer H, Chen L, Yoon G, Singer B, Yamauchi Y, *et al*. Improvement in retinal image quality with dynamic correction of the eye's aberrations. Opt. Express. http://www.opticsexpress.org/oearchive/source/31887.htm 2001;8:631-643.
6. - Navarro R, Moreno-Barriuso E, Bará S, and Mancebo T. Phase-plates for wave-aberration compensation in the human eye. Optics Letters 2000;25:236 - 238.
7. - N.Lopez-Gil, A.Benito, Castejón-Mochón JF, Marín JM, G.Lo-a-Foe, *et al*. Aberration Correction using Customized Soft Contact Lenses with Aspheric and Asymmetric Surfaces. Inves Ophtalm and Visual Sci (Suppl.) In press 2002;73:
8. - MacRae SM, Schwiegerling J, and Snyder R. Customized corneal ablation and super vision. Journal of Refractive Surgery 2000;16:230-235.
9. - Mrochen M, Kaemmerer M, and Seiler T. Wavefront-guided Laser in situ Keratomileusis: Early results in three eyes. Journal of Refractive Surgery 2000;16:116-121.
10. - Phillips A and Speedwell L. Contact Lenses. 4th Edition, : Butterworth-Heinemann, 1997.
11. - Griffiths M, Zahner K, Collins M, and Carney L. Masking of irregular corneal topography with contact lenses. CLAO J 1998;24:76-81.
12. - Atchison D. Aberrations associated with rigid contact lenses. J Opt Soc Am A 1995;12:2267-2273.
13. - Collins M, Franklin R, Carney L, Bergiel C, Lagos P, *et al*. Flexure of Thin Rigid Contact Lenses. Contact Lens and Anterior Eye 2001;24:59-64.
14. - Hong X, Himebaugh N, and Thibos L. On-eye evaluation of optical performance of rigid and soft contact lenses. Optom Vis Sci 2001;78:872-880.
15. - Marcos S, Barbero S, Moreno-Barriuso E, Llorente L, Merayo-Lloves J, *et al*. Total and corneal aberrations before and after standard LASIK refractive surgery. Investigative Ophthalmology and Visual Science 2001;42 (Suppl.):529.
16. - Navarro R and Losada MA. Aberrations and relative efficiency of light pencils in the living human eye. Optometry and Vision Science 1997;74:540-547.
17. - Navarro R and Moreno-Barriuso E. Laser ray-tracing method for optical testing. Optics Letters 1999;24:1-3.
18. - Corzine J and Klein S. Factors determining rigid contact lens flexure. Optom Vis Sci 1997;74:639-645.
19. - J. Perrigin, D. Perrigin, S. Quintero, and T. Grosvenor. Silicone-acrylate contact lenses for myopia control: 3-year results. Optom Vis Sci. 67, 764-769 (1990).
20. - A.Ho, F.Manns, T.Pham, S.Farrar. The Effect of RGP Lens Decentration on Aberration: the Influence of the Tear Lens. Inves Ophtalm and Visual Sci (Suppl.) In press 2002;73:

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❺ References

1. - Barbero S, Marcos S, Merayo-Lloves J, and Moreno-Barriuso E. Validation of the estimation of corneal aberrations from videokeratography In keratoconus. Journal of Refractive Surgery 2002;18:263-270.
2. - Moreno-Barriuso E, Marcos S, Navarro R, and Burns SA. Comparing Laser Ray Tracing, Spatially Resolved Refractometer and Hartmann-Shack sensor to measure the ocular wavefront aberration. Optom & Vis Sci 2001;78:152 - 156.
3. - Barbero S, Marcos S, and Merayo-Lloves JM. Exploring total and corneal aberrations in an unilateral aphakic subject. Journal of Cataract and Refractive Surgery. In press 2002;
4. - Fernandez EJ, Iglesias I, and Artal P. Closed-loop adaptive optics in the human eye. Optics Letters 2001;26:746-748.
5. - Hofer H, Chen L, Yoon G, Singer B, Yamauchi Y, *et al*. Improvement in retinal image quality with dynamic correction of the eye's aberrations. Opt. Express. http://www.opticsexpress.org/oearchive/source/31887.htm 2001;8:631-643.
6. - Navarro R, Moreno-Barriuso E, Bará S, and Mancebo T. Phase-plates for wave-aberration compensation in the human eye. Optics Letters 2000;25:236 - 238.
7. - N.Lopez-Gil, A.Benito, Castejón-Mochón JF, Marín JM, G.Lo-a-Foe, *et al*. Aberration Correction using Customized Soft Contact Lenses with Aspheric and Asymmetric Surfaces. Inves Ophtalm and Visual Sci (Suppl.) In press 2002;73:
8. - MacRae SM, Schwiegerling J, and Snyder R. Customized corneal ablation and super vision. Journal of Refractive Surgery 2000;16:230-235.
9. - Mrochen M, Kaemmerer M, and Seiler T. Wavefront-guided Laser in situ Keratomileusis: Early results in three eyes. Journal of Refractive Surgery 2000;16:116-121.
10. - Phillips A and Speedwell L. Contact Lenses. 4th Edition, : Butterworth-Heinemann, 1997.
11. - Griffiths M, Zahner K, Collins M, and Carney L. Masking of irregular corneal topography with contact lenses. CLAO J 1998;24:76-81.
12. - Atchison D. Aberrations associated with rigid contact lenses. J Opt Soc Am A 1995;12:2267-2273.
13. - Collins M, Franklin R, Carney L, Bergiel C, Lagos P, *et al*. Flexure of Thin Rigid Contact Lenses. Contact Lens and Anterior Eye 2001;24:59-64.
14. - Hong X, Himebaugh N, and Thibos L. On-eye evaluation of optical performance of rigid and soft contact lenses. Optom Vis Sci 2001;78:872-880.
15. - Marcos S, Barbero S, Moreno-Barriuso E, Llorente L, Merayo-Lloves J, *et al*. Total and corneal aberrations before and after standard LASIK refractive surgery. Investigative Ophthalmology and Visual Science 2001;42 (Suppl.):529.
16. - Navarro R and Losada MA. Aberrations and relative efficiency of light pencils in the living human eye. Optometry and Vision Science 1997;74:540-547.
17. - Navarro R and Moreno-Barriuso E. Laser ray-tracing method for optical testing. Optics Letters 1999;24:1-3.
18. - Corzine J and Klein S. Factors determining rigid contact lens flexure. Optom Vis Sci 1997;74:639-645.
19. - J. Perrigin, D. Perrigin, S. Quintero, and T. Grosvenor. Silicone-acrylate contact lenses for myopia control: 3-year results. Optom Vis Sci. 67, 764-769 (1990).
20. - A.Ho, F.Manns, T.Pham, S.Farrar. The Effect of RGP Lens Decentration on Aberration: the Influence of the Tear Lens. Inves Ophtalm and Visual Sci (Suppl.) In press 2002;73: