

Shared  Vision

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Higher Order Aberration Considerations in Contact Lenses



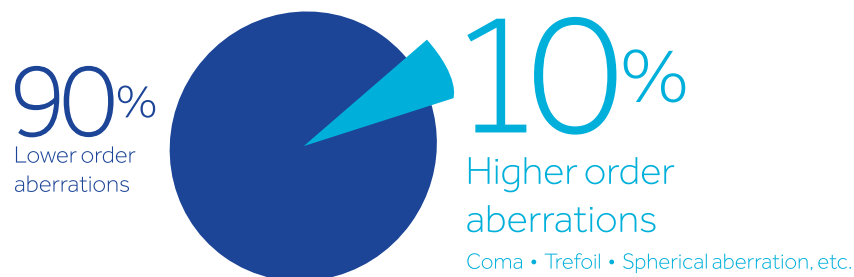
The human eye is a wonderfully complex optical system.

Similar to every complex system is the likelihood for error and unexpected variations. Irregularities of the eye may cause incoming light waves to stray from the optimal path. These deviations, or distortions, are known as optical aberrations.¹

Lower order aberrations, including myopia, hyperopia, and astigmatism account for approximately 90% of the aberrations found in the human eye.¹

Meanwhile, higher order aberrations (HOA), such as coma, trefoil, and spherical aberration account for approximately 10% of the eye's aberrations and are corrected only with specially modified glasses, contact lenses, or surgeries.^{1,2}

Optical aberrations



Perhaps the rising emphasis and interest of HOA correction has resulted from the advancement in wavefront sensors and technology which allow for the detection and subsequent correction of HOA. HOA exist and decrease retinal image quality even in the presence of best correction of myopia, hyperopia, and astigmatism.³ HOA are clinically significant since they can cause symptoms of glare, halos, diplopia, starburst patterns, and difficulty seeing at night. It has been proposed that every eye has some amount of HOA.⁴

Interestingly, HOA are believed to be relatively similar between an individual's right and left eyes.⁵ Also, clinically important is the report of HOA increasing significantly with increased pupil size, as when comparing 3 mm to 7 mm pupil diameters.⁵⁻⁷ It is understandable why vision may be degraded by HOA with night driving or reading a menu in dim lighting conditions.

HOA can cause symptoms of

- ✓ glare
- ✓ halos
- ✓ diplopia
- ✓ starburst patterns
- ✓ difficulty seeing at night

Two of the most commonly occurring HOA are coma (a third order aberration) and spherical aberration (a fourth order aberration).¹ For coma error, a point image may instead appear with a tail and more comet-like, and with spherical aberration, a point image may appear blurred or with halos.^{4,8}

2 commonly occurring HOA

- ✓ Coma
- ✓ Spherical aberration

Understanding the relationship of HOA and refractive error development may provide useful information for myopia prevention and control. Numerous studies have attempted to find a correlation between refractive error and HOA and the results have varied greatly.

Recent research has stated that hyperopes compared to myopes showed greater levels of HOA^{9,10} while other research has shown greater amounts of HOA for myopic versus emmetropic eyes.^{11,12} Furthermore, some research has stated no significant differences in the magnitude of HOA across various refractive groups.¹³ Therefore, this apparent lack of consistent relationships between HOA and refractive error may be a result of different studies utilizing differing modes of measurement, ethnicities, sample sizes, classifications of refractive errors, and age.¹³

Longitudinal evaluation of HOA and refractive error with repeated measurements of the same children over a period of time may provide more definitive information regarding the association of HOA and refractive error.³ Presently, it is not certain if HOA have a significant effect on myopia increase and if HOA occur before or after the start of myopia.¹⁴

Since image degradation, halos, glare and other hindrances have been associated with HOA, could it be possible that HOA may actually play a role in enhancing vision? Based on recent research, the answer seems to be “yes.” Soft multifocal contact lenses containing selective HOA seem promising for the control of myopia.^{3,15,16} While not certain, one hypothesis is that HOA degrade image quality for points posterior to the retina which subsequently prevents axial elongation.¹⁶

In contrast, contact lenses containing negative spherical aberration may increase the relative peripheral hyperopia and therefore, possibly promote the progression of myopia.¹⁵ Recently, a surprisingly large number of commercially available soft contact lenses, both single vision and multifocal, displayed measured negative spherical aberration.^{15,17} Therefore, lens design is important when considering myopia control for patients.

While HOA can degrade image quality, some redeeming qualities of HOA may be surprisingly useful for vision correction and enhancement. Knowing which particular HOA exist in the eye and the HOA present in corrective lens materials will benefit our patients.



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