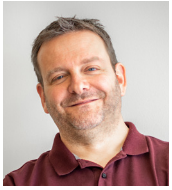
Contact Lens Update
CLINICAL INSIGHTS BASED IN CURRENT RESEARCH

Contact Lens Optics

June 15, 2021



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Richdale K, Cox I, Kollbaum P, et al. CLEAR – Contact lens optics. Cont Lens Anterior Eye 2021;44:220-39

Contact lens design has come a long way since their initial development in the late 1880s.[1] Arguably, the most critical component required for contact lenses to provide clear vision are their optics or, more accurately, the optical system that is created by the sum of the ocular and lens optics. The CLEAR report on Contact Lens Optics provides a thorough review of the optical systems employed by contact lenses to correct refractive error and aberrations.[2]

Contemporary contact lens designs

Spherical soft contact lenses are successfully used for the correction of spherical or small astigmatic refractive errors. While the human eye itself produces low level spherical aberration (SA), their combination with the SA produced by the optics of spherically curved lenses (negative SA in minus lenses and positive SA in plus lenses) may result in unwanted visual effects for the wearer depending on their magnitude and sign. Decentration of spherically surfaced contact lenses in relation to the line of sight may cause additional aberrations that may further impact the visual performance of lenses for some wearers.

In order to improve alignment with the line of sight and to reduce the inherent SA with spherically surfaced lenses, some manufacturers have developed lenses with **aspheric** lens profiles. While these attempts have shown promise in reducing SA, decentration of aspheric lenses from the line of sight – with most soft lenses typically decentring temporally from the pupil centre – may result in significant levels of other unwanted aberrations. It has yet to be determined which approach in the correction of aberrations in single vision lenses is most beneficial for the vision correction of most patients.

Toric soft contact lenses correct astigmatism by employing two different, perpendicularly arranged curves of differing radii. Rotational stability is crucial for toric contact lenses, and manufacturers utilize a variety of stabilization methods to ensure that the lenses' toricity aligns with the ocular astigmatism. When properly stabilized, toric soft lenses have been shown to provide significantly improved visual acuities in patients with astigmatism of ≥0.75D. Low astigmatic eyes of 0.75D to 1.00D were found to achieve visual acuities that were between 3 to 5.5 letters better than when wearing spherical lenses, while patients with astigmatism between 1.25D to 2.00D were found to gain between 8 and 12.5 letters.[3]

Multifocal lens designs were developed as an alternative to spectacle lenses for the correction of presbyopia. They can be widely sub-divided into alternating (or translating) and simultaneous lens optic designs.

Alternating designs are mainly used in rigid corneal lenses, and employ two distinct power zones for distance and near, similar to a bifocal spectacle design. Alternating designs depend on translation of the lens on eye by gaze changes; while looking straight ahead keeps the distance correction in front of the pupil for clear distance viewing, adjusting the gaze downwards will move the lens upwards, bringing the near zone in front of the pupil. Centration and stabilisation in these designs is achieved using prism ballast and/or lens truncation.

Simultaneous designs are based on lens optics that allow light rays to simultaneously pass through multiple lens zones, thereby conjointly creating the image on the retina. Simultaneous designs can be either bifocal (i.e. two distinct distance and near powers) or multifocal (with smooth transitions between different power zones). Because the simultaneous progression of the light through the bifocal or multifocal lens results in in-focus and out-of-focus zones in the retinal image, currently available lens designs need to correct for these “ghosting” effects. This is achieved using a variety of optical designs such as diffractive, annular, or extended depth of focus (EDOF).

- *Diffractive* designs employ concentric zones of varying power that are achieved by optical path length changes. Depending on the phase shift between zones, bifocal (half wavelength shift), trifocal or multifocal lenses have been designed.
- *Annular* (also known as concentric or zonal) designs incorporate a central circular zone for either distance or near correction that is surround by one or multiple concentric zones for distance and near/intermediate correction.
- *Aspheric* designs employ a gradually progressing power profile from the lens centre to the edge of the optical zone. Due to the asphericity of the lens surface(s), a progressively greater power is created in the lens centre (centre-near design, introducing negative SA) or the periphery (centre-distance design, introducing positive SA). The success of lens fits with centre-near or centre-distance lens designs is closely related to the degree of SA the contact lens adds to the SA of the wearer’s eye, as it may add to or subtract from the existing aberrations.
- *Extended depth of focus EDOF)* lens designs represent the newest addition to the multifocal lens market. These designs differ from “traditional” multifocal lens designs in as much as their power profile does not show a gradual change in power distribution but rather employs other power profiles that incorporate multiple higher order SA terms or unique angular optical elements.
- *Myopia control* lens designs have been developed by taking advantage of optical principles used for presbyopia correction, but with the goal to induce myopic defocus at the retina in an attempt to reduce myopic progression. Myopia control lens designs include annular, aspheric, multi-segment or EDOF designs. Currently, the MiSight® 1 day lens (CooperVision Inc., Pleasanton, CA, USA) is the only soft lens design that has received both FDA and European Conformity (CE) approval for slowing myopia progression.[4]

Clinical Assessment of optical design efficiency

In order to test whether a given lens design provides the patient with clarity of vision, clinicians have a variety of tests and assessments at their disposal.

Visual acuity, contrast sensitivity or rotational stability for toric lenses are routine clinical tests that help in the clinical assessment of contact lens performance. Visual acuity testing using logarithm of the minimal angle of resolution (logMAR) has been recommended due to its improved measurement repeatability and more precise specification of visual acuity.[5] With logMAR visual acuity, each letter is assigned a value of 0.02 logMAR, providing useful information when comparing the visual performance of different lens designs with the same prescription powers.

With reading and near work representing a large part of our daily lives, the assessment of near vision, particularly for bifocal or multifocal contact lens designs, is highly relevant. The most suitable clinical tests for assessing reading performance are reading acuity (the smallest letter size that can be read), reading speed (the number of words read per minute) and critical print size (the smallest line that can be read at the maximum reading speed). In addition to standard paper reading charts, new digital reading charts have been developed to more closely mimic the daily use of digital devices.

While the measurement of visual acuity is probably the most standardised and reliable measurement to assess the on-eye success of contact lens optics, it may not provide clinicians with sufficiently relevant information about the visual performance multifocal lens wearers experience in real life. Finding the most suitable multifocal lens design for a patient remains a challenge, not only because of the inherent differences in the various optical designs but also due to the patient-to-patient variation in ocular (level of aberrations, pupil size) or lens-related metrics (lens centration and movement). At this time, the need for a reliable method to predict multifocal fitting success is not yet met.

In summary, there is no “one-size fits all” contact lens, and the large inter-patient and inter-lens design variabilities may still require clinicians to fit multiple different lens design to find the most suitable contact lens for each of their patients.

Further information, for example on contact lens metrology or more detailed descriptions of the various available lens designs, can be found in the article.

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