MULTIFOCAL LENSES

IMPACT OF MULTIFOCAL POWER PROFILES ON VISUAL OUTCOMES

Consistency across each zone puts practitioners in the position to deliver excellent presbyopia correction

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Individuals with presbyopia must function in a visually dynamic world that varies widely in contrast and luminance. In a typical day, they can spend time driving in daylight and night, working on computers at work and home, surfing the Internet and making calls on a smartphone, reading, and watching television. The eyes can be constantly shifting between objects at distances that are commonly defined as “near,” “intermediate,” and “distant.”

With the onset of presbyopia beginning at about age 40 (Holden et al, 2008) and life expectancy reaching record highs of 79 years (Murphy et al, 2015), many adults will spend nearly half their lives with presbyopia. Projections of presbyopia prevalence in more developed countries indicate a growing need for presbyopia correction (Holden et al, 2008). This growing need highlights a growing opportunity for contact lens practitioners, as 42% of people 40 to 54 years of age and 38% of people 55 to 64 years of age are interested in multifocal contact lenses (Gallup, 2015). Interest in multifocal contact lenses over eyeglasses is driven by the perceptions that contact lenses are better for physically active and busy people, make people look younger, and allow them to grow older gracefully (Gallup, 2015).

Manufacturers of progressive multifocal contact lenses offer varied optical designs to address patients’ needs. For these simultaneous-image lenses, image quality can play an important role for processing visual information to enhance the user’s experience. Producing a contact lens that can meet patients’ vision needs for every task is a challenge for lens designers.

ADVANCING THE DESIGN OF PROGRESSIVE MULTIFOCAL CONTACT LENSES

With single-vision contact lenses, light passes through the single power of the optic zone and the pupil to form a focused retinal image. Progressive multifocal contact lenses present simultaneous information of focused and unfocused images on the retina. While the focused image is influenced by the unfocused image (Charman and Saunders, 1990), the brain selects the focused image and suppresses the unfocused image (Benjamin, 1993).

Significant advancements have been made in the ability to measure an individual’s ocular profile that contributes to focusing light on the retina. Specific ocular biometry and aberrations of an eye can contribute to the image quality received by the retina (Liang and Williams, 1997; Yuan et al, 2013; Shi et al, 2012). In optimizing advanced multifocal lens designs, accounting for the variety of individual biometric factors and

Figure 1. Design variables.
vision tasks. Power profiles offer a convenient way to evaluate the optics of a lens design.

An analytical approach to estimating the retinal image quality for near, intermediate, and distance vision is to divide the area of the optic zone into three zones consisting of a central circular near zone, a middle annular intermediate zone, and an outer annular distance zone. Three manufacturers of progressive multifocal contact lenses offer varied optical designs to address patients’ needs.

In this analysis (Reindel et al, 2015), power profiles were generated using the NIMO TR1504 wavefront analyzer (Lambda-X, Belgium) for the following lens designs:

- Air Optix Aqua Multifocal (lotrafilcon B; Alcon) –3.00D, high add
- Bausch + Lomb Ultra for Presbyopia (samfilcon A; Bausch + Lomb) –3.00D, high add
- Biofinity “N” Multifocal (comfilcon A; Cooper Vision) –3.00D, +2.50D add.

Five lenses in each material were measured over a 6 mm diameter. Distance, intermediate, and near vision zones were defined, and change in power across distinct zones was assessed to optimize predicted visual outcomes (Figure 1).

Adjusting the diameters of the near and intermediate zones and the change in power within these zones allowed balancing light energy to improve near and intermediate visual outcomes. The final 3-zone progressive design was selected based on the optimal visual outcomes across the nine distances (6 m, 2 m, 1 m, 67 cm, 50 cm, 40 cm, 33 cm, 28 cm, and 25 cm) and “real world” experiences of patients wearing the multifocal low- and high-add lenses.

**POWER PROFILE ANALYSIS**

Light passes through zones of the multifocal contact lens and the pupil to form the retinal image in simultaneous-image contact lenses. The distribution of power across the distance, intermediate, and near zones of progressive multifocal contact lenses plays a critical role in concentrating light to meet sustained and dynamic aberrations is important because contact lens wearers will judge their effectiveness based on image quality provided during their daily activities.

Traditionally, conventional multifocal contact lens designs use refractive error or refractive error and pupil size in optical design development. In contrast, additional factors were also considered in the development of a novel 3-Zone Progressive lens design. In addition to refractive error and pupil diameter, the design accounted for accommodative amplitude, depth of focus, higher-order aberrations, pupil changes as a function of object distance, corneal curvature, axial length, and residual accommodation across nine distances. The diameters of a near zone and an intermediate zone, total add power, and change in power across distinct zones were assessed to optimize predicted visual outcomes (Figure 1).

Figures 2 to 4 illustrate the averaged power profiles for each of the three lens designs. With the 0 mm radial distance indicating the lens center, the shaded regions represent the near, intermediate, and distance regions where change in power was calculated. Table 1 summar-
rizes the change in power results for the three designs.

For the Air Optix Aqua Multifocal lenses, the power changes within the distance, intermediate, and near zones were 0.33D, 0.45D, and 0.32D, respectively. The change for all three zones was significantly greater than 0.25D (P<.05). For the Bausch + Lomb Ultra for Presbyopia lenses, the power changes within the distance, intermediate and near zones were <0.25D. For the Biofinity “N” Multifocal lenses, the power change within the intermediate zone was 1.19D which was significantly greater than 0.25D (P<.05).

**INNOVATIVE DESIGN FOR CONSISTENT POWER AT EACH DISTANCE**

Multifocal contact lenses have become the preferred option for meeting the needs of patients with presbyopia who are interested in contact lens wear (AOA, 2014). While each generation of presbyopic individuals may use digital technology differently, Boomers and Gen Xers rely heavily on computers and smartphones on a daily basis (Milward Brown Digital, 2015). A recent survey among a presbyopic population found that 61% look at multiple screens/use multiple digital devices at the same time, and 58% experience eye strain or vision problems as a direct result of using technology (AOA, 2015).

Progressive multifocal contact lenses control the rate of change in power for each distinct zone responsible for distance, intermediate, and near vision as a means to manage the amount of focused and unfocused light on the retina for objects. Sustained tasks on digital devices and switching between digital devices can impact the contact lens wearer’s experience. Sharp, clear vision at near and intermediate distances are the key drivers of multifocal contact lens satisfaction, followed by effort-

<table>
<thead>
<tr>
<th>REGION</th>
<th>CONTACT LENS</th>
<th>Δ POWER</th>
<th>Δ &gt;0.25D</th>
<th>P values</th>
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</thead>
<tbody>
<tr>
<td>NEAR</td>
<td>Air Optix Aqua Multifocal</td>
<td>0.33D</td>
<td>&lt;.01</td>
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<tr>
<td></td>
<td>Bausch + Lomb Ultra for Presbyopia</td>
<td>0.08D</td>
<td>&gt;.99</td>
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<tr>
<td></td>
<td>Biofinity “N” Multifocal</td>
<td>0.06D</td>
<td>&gt;.99</td>
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<td>&lt;.01</td>
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<td>Bausch + Lomb Ultra for Presbyopia</td>
<td>0.08D</td>
<td>&gt;.99</td>
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<tr>
<td></td>
<td>Biofinity “N” Multifocal</td>
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<tr>
<td>DISTANCE</td>
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<td>0.10D</td>
<td>&gt;.99</td>
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The Bausch + Lomb Ultra for Presbyopia contact lens is the result of extensive research involving 576 individual eye models incorporating biometric data, including refractive error, residual accommodation, higher-order aberrations, and pupil size, to optimize the concentration of light energy within each zone (Kingston and Cox, 2013). The power profile analysis demonstrates that the optical design of the Bausch + Lomb Ultra for Presbyopia lens has 3 distinct zones with consistent power for focusing near, intermediate, and distant objects on the retina.
CONCLUSION

Power mapping is a useful tool to evaluate relative similarities and differences in power profiles of aspheric multifocal contact lenses. With varied viewing distances for digital devices, three distinct zones that concentrate light should provide excellent utility for advanced presbyopia.

REFERENCES


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