ZEISS Digital Lens:

A New Pre-progressive Lens Designed for Digital Eye Strain

By Darryl Meister, ABOM

Modern society increasingly relies on visual interaction with computers and mobile devices. The visual demands that these digital display devices place on the mechanisms of accommodation and convergence often result in blurred vision, eye strain, and other symptoms associated with digital eye strain or computer vision syndrome, even before the full onset of presbyopia. With the introduction of ZEISS Digital Lens, patients in their 30s and 40s now have an effective optical solution tailored to their unique visual requirements.

Digital Eye Strain in the Modern Visual Environment

Our interaction with the world around us is becoming increasingly dependent upon visual interaction with digital display devices. Computers have become ubiquitous at both home and the workplace. Additionally, the rapid proliferation of mobile computing devices, including smartphones and tablets, has created an important new medium for interacting with digital content. However, the convenience and productivity afforded by computers and mobile devices have come at the expense of increased vision problems and related symptoms, clinically referred to as *computer vision syndrome* or, when referring to the overuse of digital display devices in general, as *digital eye strain*.

The incidence of vision problems related to digital displays has increased along with our reliance on these devices. Studies have shown that up to 75% of computer users may experience vision-related symptoms, including eye strain, headache, blurred near vision, post-work distance blur, and neck or shoulder pain due to viewing-related postural adjustments.[1] Mobile device users may suffer from similar symptoms. In fact, a recent survey conducted by the Vision Council revealed that over two-thirds of adults who regularly use digital display devices experience symptoms associated with digital eye strain (Figure 1).[2] However, only 8% of these adults have tried optical lenses to alleviate these symptoms.

Mature presbyopes are not the only patients at risk. It has been estimated that 33% of symptomatic computer users who are not yet presbyopic may suffer from accommodative disorders related to their use of computers.[3] Consequently, *pre-presbyopic* patients, in their 30s and 40s, may also present with symptoms caused by computer vision syndrome or digital eye strain, even those who might otherwise demonstrate normal accommodative function for their age. Although blurred near vision may not always be reported during their medical history, pre-presbyopic patients may still suffer from other symptoms, such as eye strain or headache.

Digital eye strain occurs when the viewing demands placed on the visual system exceed the capacity of the accommodative and vergence systems to maintain clear and comfortable vision. During sustained viewing tasks involving a computer or mobile device, the ciliary and extraocular muscles of the eyes must work constantly to maintain proper focus and alignment. Like repetitive strain injury, frequent eye movements combined with constant neuromuscular demand on accommodation and convergence can eventually lead to dysfunction and, ultimately, to eye strain. Visual strain can also lead to tension in the muscles of the face that may precipitate headache and drowsiness by the end of the day.[4]

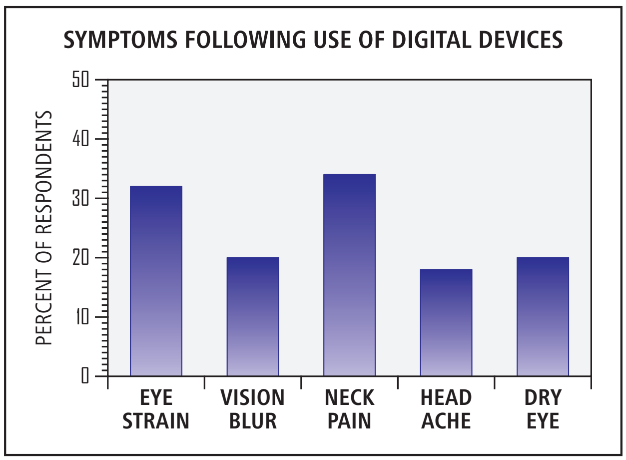


Figure 1. A recent survey by the Vision Council revealed that over two-thirds of adults who use digital display devices regularly experience a variety of symptoms associated with digital eye strain, including eye strain, blurred vision, neck/shoulder pain, headache, and dry eye (n = 10 000).

Implications of Digital Displays for Near Vision

When focusing on objects at near, the eyes must precisely converge to align with the point of fixation and accurately accommodate to bring the image into focus. The mechanisms of accommodation and convergence are physiologically linked within the visual system, resulting in a certain amount of *accommodative convergence* in response to an increase in accommodation when focusing at near. The ability of the eye to accommodate gradually decreases with age due to a progressive loss in the elasticity of the lens, eventually resulting in *presbyopia* when the eye can no longer comfortably sustain focus at the desired reading distance.[5]

The *amplitude*, or maximum available amount, of accommodation decreases by roughly 0.29 D per year, eventually diminishing to 1 D by age 60 years.[6] A common clinical guideline for prescribing a near addition is to leave 50% of the available accommodation in reserve in order to provide clear and comfortable vision during sustained reading tasks.[7] Given a typical viewing distance of 30 cm for mobile devices, equal to 3.33 D of demand, this implies that additional plus power may be required at near once the amplitude of accommodation falls below $2 \times 3.33 = 6.67$ D. This will occur between 31 and 42 years of age for most patients (Figure 2).

But many patients will refrain from seeking a spectacle correction for near vision problems as long as possible, choosing to tolerate blurred vision and discomfort, rather than acknowledging the need for "reading glasses," a sign of aging.[8] Further, symptoms associated with near vision problems are not necessarily restricted to the mature presbyope. Our increasing reliance upon computers and mobile devices, intensive use of which can become particularly strenuous on the visual system, may result in symptoms associated with near vision disorders among many patients earlier in life, even at ages traditionally associated with pre-presbyopia.

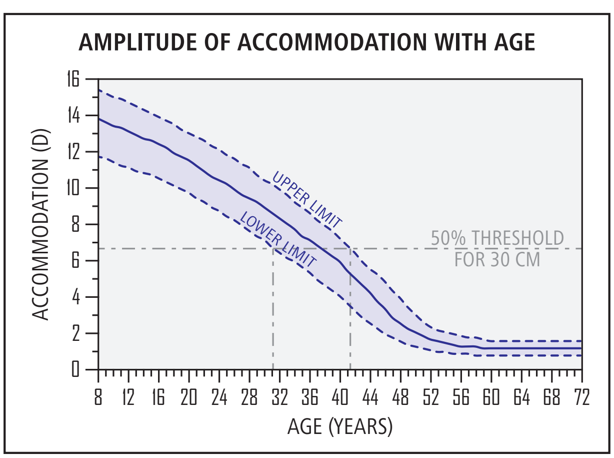


Figure 2. The ability of the eye to bring objects at near into focus decreases with age, eventually resulting in blurred near vision, eye strain, and other symptoms, once adequate accommodation is no longer available.

The strain on the accommodative and vergence systems that results from prolonged viewing of computers and mobile devices can elicit symptoms of blurred near vision, asthenopia (eye strain), and headache. Accommodative function decreases after prolonged near viewing, resulting in reduced amplitude of accommodation and reduced *facility of accommodation*, or the ability of the eye to change accommodation quickly in response to changes in viewing distance. Moreover, sustained vision at near viewing distances can increase the tonic level of accommodation, resulting in a period of blurred distance vision after near work.[9]

It has also been theorized that the demand for sustained concentration during near vision causes the mechanism of convergence to localize closer to the body than the mechanism of accommodation.[10] The resulting mismatch between convergence and accommodation may interfere with visual efficiency and comprehension, resulting in asthenopia and impairing the ability to sustain near vision. Further, the actual accommodative response is often less than the accommodative demand required for precise focusing, resulting in a *lag of accommodation* that may contribute to the disparity between accommodation and convergence.

Although digital displays have improved over the years, strain on the visual system is exacerbated by additional factors that are unique to digital display devices. The legibility of text on digital displays is often poorer than text on printed materials, due to lower image contrast and resolution, resulting in a lower quality stimulus to accommodation that may reduce visual performance and comfort after sustained viewing.[11] Additionally, mobile devices are usually held at shorter viewing distances compared with traditional reading materials, which requires even greater exertion of accommodation and convergence (Figure 3).[12]

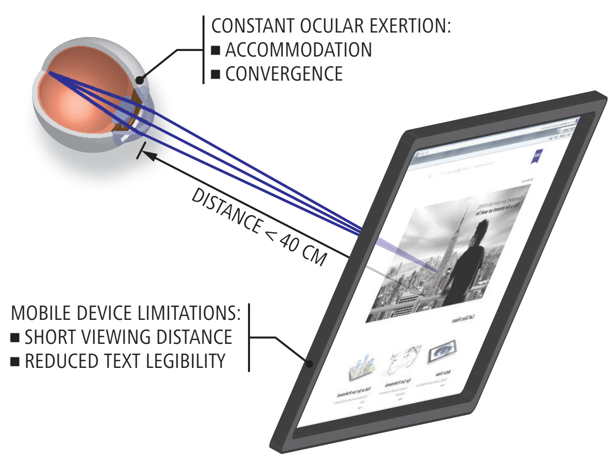


Figure 3. The visual limitations of mobile devices, including reduced text legibility and a short viewing distance, may exacerbate symptoms attributed to overexertion of accommodation and convergence.

Designing Lenses for a Digital World

A single-vision correction for distance vision may fail to alleviate symptoms associated with computer vision syndrome or digital eye strain. However, the use of a low addition power over the distance correction, up to +1.25 D, has been recommended as an effective treatment for the complex of vision problems associated with accommodative dysfunction among symptomatic pre-presbyopes with intensive near-vision demands.[9,10] In order to provide these patients with a spectacle correction better tailored to their visual requirements, Carl Zeiss Vision has recently introduced ZEISS Digital Lens. Digital Lens has been specifically designed for the visually strenuous demands of our modern "digital" world.

The visual requirements of pre-presbyopes differ from those of mature presbyopes in two ways that have important implications for any kind of progressive lens design. First, previous single-vision wearers will be accustomed to unrestricted distance vision that is free from blur and distortion. Second, because these wearers can often read clearly without additional power, the near zone must be easily reached with minimal head or eye movement in order for the wearer to enjoy any therapeutic benefit provided by the supplemental plus power. Conventional progressive lenses may fail to address these requirements adequately.

ZEISS Digital Lens relies on low-powered progressive optics to provide supplemental addition power, which precludes the need for telltale bifocal lines, while providing more physiologically natural vision. However, the distribution of progressive optics over Digital Lens has been specifically tuned to the needs of previous single-vision wearers based upon the results of wearer trials comparing different experimental lens designs. First, the start of the progression of power—and, therefore, the accompanying peripheral blur—has been lowered relative to the distance zone in order to provide a more single-vision-like viewing experience compared with conventional progressive lenses (Figure 4).

Second, the length of the progression of addition power has been shortened in order to provide more easily accessible addition power for near vision. The optics and position of the near zone of Digital Lens have been specifically calculated for the optimum viewing of mobile devices, typically held at just over 30 cm. These lens design improvements have been achieved by essentially compressing the length of the intermediate zone in order to emphasize the utility of the more critical distance and near zones (Figure 5). A large intermediate zone is not necessary for this lens design, because the relatively low addition power provided by the near zone will also keep mid-range objects in focus out to at least 80 cm.

The unique *pre-progressive* lens design of ZEISS Digital Lens provides just enough supplemental addition power to offset the load on accommodation. Distance visual acuity is maintained, while the addition power is reached without awkward postural adjustments that could result in musculoskeletal strain. Moreover, unlike conventional progressive lenses, which typically have addition power ranges that start at +0.75 or +1.00 D, Digital Lens is available with addition powers ranging from +0.50 to +1.25 D.

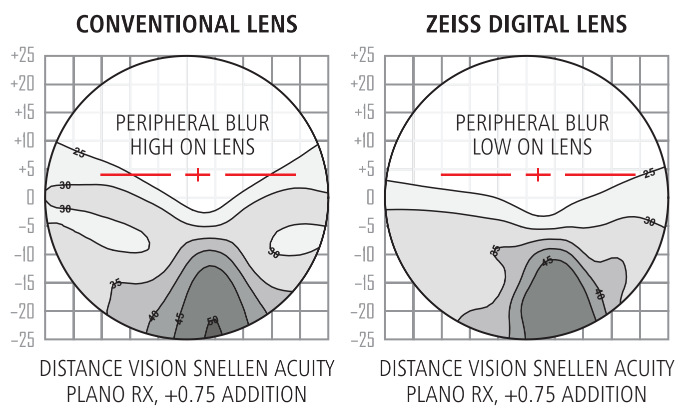


Figure 4. Unlike conventional progressive lenses, ZEISS Digital Lens provides a more single-vision-like viewing experience by lowering the progression of power and peripheral blur relative to the distance zone.

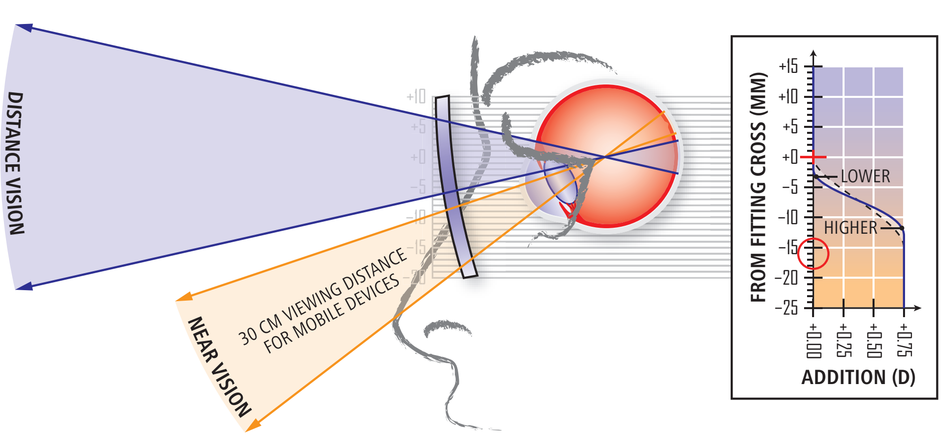


Figure 5. The distribution of progressive optics over ZEISS Digital Lens has been tuned to the needs of pre-presbyopes by lowering the progression of power relative to the distance zone and by reducing the length of the progression of addition power in order to provide easily accessible reading utility, ergonomically positioned for mobile devices.

An Effective Solution to a Widespread Problem

The frequent use of digital display devices throughout the day may ultimately result in blurred vision, eye strain, headache, or even drowsiness by the end of the day due to the prolonged stress placed on the visual system and associated musculature. Of course, for the mature presbyope, conventional progressive lenses are typically prescribed to alleviate symptoms associated with computer vision syndrome or digital eye strain. A dedicated pair of progressive lenses specifically for computer use, such as ZEISS Officelens, may also be indicated. For the pre-presbyope, however, optical solutions have often met with mixed success.

Both *anti-fatigue* and *starter progressive* lens designs have been introduced to alleviate the load on accommodation for symptomatic patients. However, these two product categories have often met with resistance among wearers due either to the optical choices made for the lens design or to the psychological implications associated with the product positioning. Paramount to the success of a spectacle lens intervention for the treatment of digital eye strain among younger patients is a lens design that will work well while avoiding emotional barriers to acceptance.

Anti-fatigue lenses that provide a fixed progressive addition power have yet to achieve widespread acceptance. Arguably, the intended patient population for anti-fatigue lenses has yet to be clearly defined. Further, the optical designs within this new category of lenses may leave room for improvement. In fact, during the development of ZEISS Digital Lens, vision scientists at Carl Zeiss Vision tested the preliminary Digital Lens design against a popular anti-fatigue lens as well as a single-vision control among 63 test subjects. Significantly more subjects ranked Digital Lens as their first choice compared with the anti-fatigue lens (Figure 6).[13]

Starter progressive lenses that have been modeled after general-purpose progressive designs, on the other hand, may fail to address the unique visual requirements of pre-presbyopes. Further, starter progressive lenses are still positioned as "no-line bifocal" lenses for the correction of an age-related vision defect. Consequently, younger patients who are still coming to terms with the need for optical assistance while reading may resist this recommendation, particularly if they have presented with digital eye strain symptoms that do not include blurred near vision. Further, addition powers for starter progressive lenses are not available below +0.75 D.

With the requirements of pre-presbyopes in mind, vision scientists and lens designers at Carl Zeiss Vision have developed the ideal optical solution for symptomatic patients who may benefit from supplemental addition power from +0.50 to +1.25 D. Further, because Digital Lens is not positioned as a "no-line bifocal" lens, the psychological implications associated with the transition of patients in their 30s and 40s into spectacle lenses with addition power is greatly improved. Their vision problems can therefore be addressed without the accompanying emotional barrier.

Vision scientists at Carl Zeiss Vision tested the efficacy of ZEISS Digital Lens among 49 pre-presbyopic subjects. Of those, 41 subjects experienced eye fatigue at the end of the day with their habitual correction. After two weeks of wear with Digital Lens, however, 46% of the symptomatic subjects no longer experienced eye fatigue. Differences in accommodative facility were also evaluated. On average, subjects were able to alternate fixation from near to far 46 times with Digital Lens in 2 minutes compared with only 25 times with their habitual correction ($p < 0.01$).[14] This represents a significant improvement in accommodative facility.

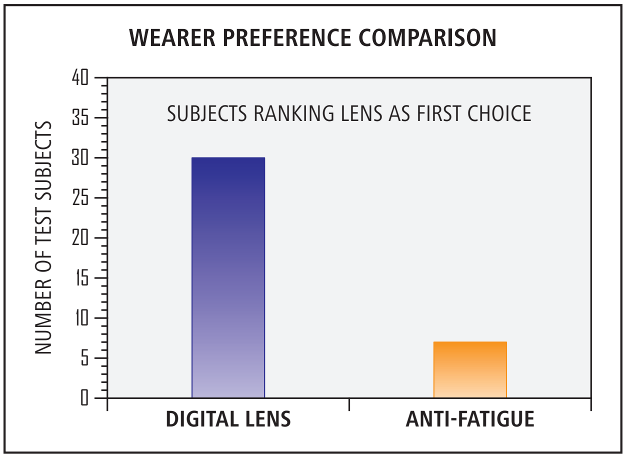


Figure 6. In an internal wearer trial conducted during the development of ZEISS Digital Lens, the preliminary Digital Lens design was chosen as the best lens by significantly more subjects than a popular anti-fatigue lens using a randomized, cross-over study design (n = 63).

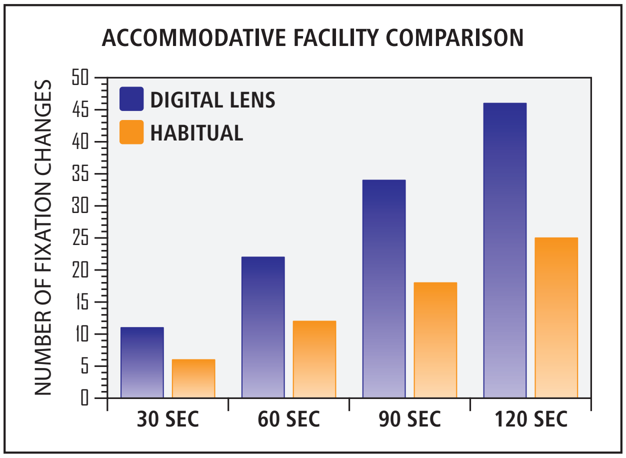


Figure 7. In a study conducted to investigate the accommodative facility of subjects wearing ZEISS Digital Lens, subjects were able to alternate fixation from near to far nearly twice as many times in 2 minutes while wearing Digital Lens compared with their habitual correction (n = 49).

Digital Revolution in Vision Care

Since the invention of the transistor in 1947, the Digital Revolution has been reshaping some of the most important facets of our lives, first by moving the world from analog to digital technologies and then by ushering in a new era of communication with the Information Age. Consumer research has shown that adults are spending increasingly more time each day with these new technologies (Figure 8).[15] Unfortunately, because the physiology of the human visual system is not well-adapted to the visual demands of modern society, a significant percentage of these adults will suffer from symptoms associated with digital eye strain.

While our usage of digital devices that place greater demands on our visual system has increased, so has our desire to maintain a healthy, youthful appearance. For instance, the number of surgical and non-surgical cosmetic procedures conducted annually in the United States has increased by 500% over the past 15 years.[16] It is also no secret to clinicians that many emerging presbyopes will refrain from seeking treatment for their near vision problems for as long as possible due to the psychological implications associated with the linkage between aging and the need for reading glasses.

The introduction of ZEISS Digital Lens has now provided eyecare professionals with a superior alternative for their pre-presbyopic patients suffering from digital eye strain. Digital Lens has been specifically designed for the visual requirements of pre-presbyopes who frequently use computers and mobile devices. The product positioning of Digital Lens is also intended to appeal more to patients in their 30s and 40s who might otherwise be reluctant to wear ”no-line bifocal” or “starter progressive” lenses. Moreover, Digital Lens reflects the award-winning approach to lens design that is the hallmark of all ZEISS lenses, ensuring easy adaptation into other ZEISS lenses as the wearer’s presbyopia advances.

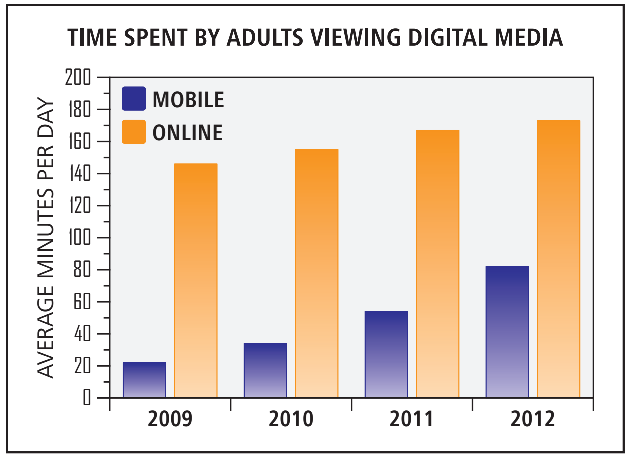


Figure 8. Consumer research indicates that adults in the United States now spend on average 173 minutes each day online (using a computer or mobile device) and 82 minutes each day using a mobile device to access digital media content, which continues to reflect an increasing trend in the usage of digital display devices.

Finally, unlike traditional progressive lenses, fabricated from mass-produced semi-finished lens blanks, every ZEISS Digital Lens is customized for the wearer’s specific prescription using real-time optical optimization. By fine-tuning the optical design of the lens for the exact prescription, residual optical aberrations that could otherwise reduce image quality, restrict the field of view, and disrupt binocular fusion are virtually eliminated, resulting in wider, more symmetrical fields of clear vision compared with traditional lenses (Figure 9). Because even small uncorrected refractive errors and binocular vision problems can exacerbate symptoms associated with digital eye strain due to the visually demanding nature of computer and mobile device use,[17] advanced features such as this make ZEISS Digital Lens the ideal optical solution for your pre-presbyopic patients.

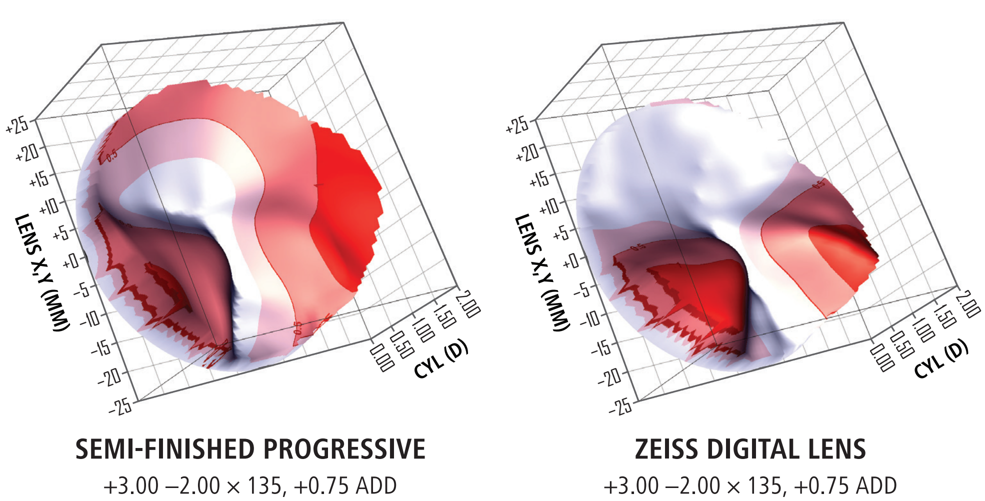
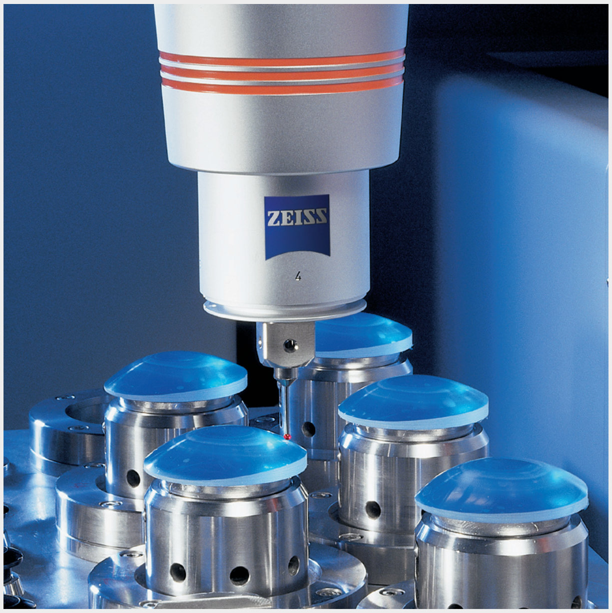


Figure 9. Unlike semi-finished progressive lenses, which suffer from optical aberrations that can shrink and distort the field of clear vision in many prescription combinations, every ZEISS Digital Lens is optically optimized for the exact prescription in order to provide consistently wide, symmetrical viewing zones to every wearer, as demonstrated by these plots of ray-traced astigmatism (cylinder) error.

Digital Lenses Delivered with Digital Manufacturing

Every ZEISS Each Digital Lens is individually manufactured using precision digital lens surfacing. As one of the earliest pioneers in the production of free-form lenses using digital lens surfacing, Carl Zeiss Vision has unparalleled expertise in this manufacturing technology. Digital Lens relies on proven ZEISS technology that integrates patented back-side optics with extensive process engineering and ongoing quality control. Each ZEISS Digital Lens design is directly surfaced onto the back of the lens blank by a precision free-form generator, which ensures extremely accurate replication of the lens design. Placing the progressive optics on the back surface also minimizes image swim and skew distortion by eliminating the contribution of unwanted magnification effects due to front surface "shape."

Each ZEISS Digital Lens is customized for the exact prescription requirements of the individual wearer using real-time optical design combined with sophisticated numerical optimization methods. Residual optical aberrations are virtually eliminated, resulting in wider fields of clear vision with better binocularity compared with traditional lenses. Further, each Digital Lens is customized for the frame chosen by the wearer using a continuously variable progressive corridor length. The corridor length is automatically sized based upon the specified fitting height in order to maximize the viewing zones of the lens design for the available lens area inside the frame, down to a minimum fitting height of 13 mm. These advanced technologies maintain the intended optical performance of the lens design for all wearers.



Each ZEISS Digital Lens is individually manufactured using digital lens surfacing that relies on patented back-side progressive optics combined with extensive process engineering and ongoing quality control in order to deliver high-quality, precision optical lenses to wearers.

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