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Effective Pharmacologic Treatment of Presbyopia Requires Adequate Pupil Reduction: Optimal treatment requires a pupil diameter smaller than 2 mm

As people age, their ability to focus at near is reduced. This typically becomes visually significant when people approach their mid- to late 40s. The term for this is presbyopia, losing the ability to accommodate. Dr. Colman Kraff, Kraff Eye Institute, Chicago, Illinois, said, "We lose the ability to accommodate due to hardening of the lens. So we lose that near vision."

Much of the current activity in presbyopia treatment is based on constricting the patient's pupil size, restoring near vision through an expanded depth of field to increase depth of focus. Different approaches are emerging, and some will be more effective than others.

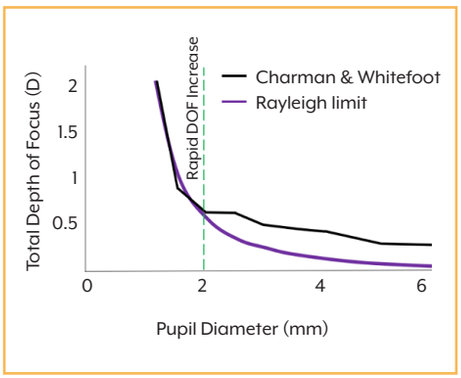

Figure 1. The size of the pupil correlates to the total depth of focus—the smaller the pupil, the greater the depth of focus.[4]

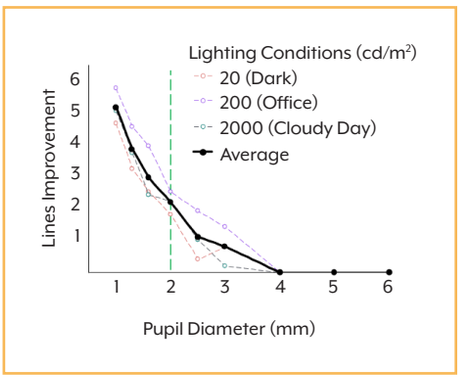

Figure 2. Reducing pupil diameter improves near vision across a broad range of lighting conditions.[3]

Improving Depth of Field

Depth of field refers to the distance between the closest and furthest objects that remain in focus[1]—in other words, the area of vision that is in sharp focus.

Channeling light through a small aperture blocks peripheral and unfocused rays, enhancing focus and extending the depth of field of an optical system.[1] This is often discussed as the "pinhole effect," in eyes as well as in cameras. The magnitude of depth of field varies inversely with pupil diameter—the smaller the pupil, the larger the acceptable depth of field.[2] This has also been seen with some newer IOLs that have different aperture sizes, typically around 1.36 mm.

Expanding Depth of Focus

Depth of focus can be described as lines of light rays that come into focus on the retina, inside the eye. As with depth of field, the size of the pupil correlates inversely to the depth of focus. The smaller the pupil, the greater the depth of focus. The graph in Figure 1 shows what both theoretical and human data-based research have found: Reducing the pupil diameter below 2 mm dramatically increases depth of focus.[4]

Dr. Kraff explained, "When you constrict the pupil you concentrate light that enters the eye. There aren't as many peripheral rays of focus, it's more direct, so it's focused directly onto the back of the eye. As the pupil, or aperture, narrows, it expands the depth of focus, causing an extended depth of field."

A small aperture also reduces the effect of corneal aberrations on vision. Paraxial light rays that are less susceptible to aberrations will pass through the small pupil aperture to reach the retina, while light rays from the more peripheral and aberrated cornea will be blocked. Small pupils consequently reduce the effect of corneal aberrations.[1]

These effects combined mean that when the pupil is constricted below 2 mm as shown in the literature,[3,4,5] there can be a significant increase in the depth of field, resulting in expanded depth of focus and improved near visual acuity.

Optimal Pupil Size

Figure 2 shows that reducing pupil diameter improves near vision across a wide range of lighting conditions.[3] Miotic eye drops target pupil size reduction and have the benefit of constricting the pupil at the iris plane, which reduces concerns of centration issues that could occur with IOLs. The best way to ensure centration of miosis is to use the patient's own pupil.

Because of this, an eye drop that doesn't constrict the pupil diameter below 2 mm will not result in enough dioptric change, so it also requires a patient to accommodate in order to achieve their optimal near vision. In older patients, this accommodation is essentially gone, and therefore, a pupil below 2 mm is essential for an effective drop to provide meaningful reading/near benefit.

Conclusion

Effective pharmacologic treatment of presbyopia requires adequate pupil reduction. The smaller the pupil, the greater the range of depth of focus and near vision improvement. Both theoretical and human data-based research have found that reducing the pupil diameter below 2 mm dramatically increases depth of focus and improves near vision across a wide range of lighting conditions.[3,4,5]

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