Introduction

The increase in power from the top to the bottom of a progressive lens creates increasing amounts of prism which induces increasing degrees of image deviation.1 This distortion becomes most noticeable and most disturbing during dynamic vision, where it produces the well-known “swim effect.”2-4 While optical designers have long worked to minimize “swim,” it has been impossible with prior technology to do so without also reducing visual field size.

One can quantify the “swim effect.” The difference in horizontal displacement of a vertical line seen through the upper and the lower portions of the lens is a value we can call Ax. This value is a function of the top-to-bottom change in power and the shape of the lens. By dividing Ax by the maximum power variation AP, we can derive an objective criterion of “swim,” ∆d, which is the end-to-end normalized deformation. To minimize “swim,” ∆d must be close to 0, as it is in a single vision lens.

Challenged to reduce “swim” without decreasing field size, Essilor scientists explored every aspect of the lens design process. The result was a revolutionary new design technology called Nanoptix Technology”, which conceptualizes the lens as composed of tiny optical elements, each of which can be individually corrected to bring ∆d close to zero, while respecting the progressive gradient. This study used virtual reality simulation to provide proof-of-concept that this revolutionary lens geometry could produce clinically meaningful results.

Methods

The effects of any given curve on the image of a physical object (eg, a grid) can be mapped (Figure 1) and then modeled in a virtual reality environment (Figure 2).5 This study used a virtual reality simulator to compare the effects on dynamic vision of two lens designs: a classic progressive lens design and a design with the new geometry designed to reduce “swim.”

Using the virtual reality simulator, 10 subjects were shown two images of a grid and asked to compare the images in dynamic vision. Presented in random order, one was a grid as it would be seen through a standard progressive lens geometry. The other was a grid as it would be seen through a new “swim” geometry.

Results

Comparing the grids in dynamic vision, the group produced by the optimized geometry was preferred in 62% of the comparisons. The grid produced by the standard progressive design was preferred in 23% (Figure 3). There was no preference in 15% of the comparisons.

Conclusion

In this study, Essilor vision scientists demonstrated that “swim” could be quantified, and that an innovative lens geometry could provide a clinically meaningful reduction in “swim.” Study subjects clearly preferred the virtual reality image provided by the revolutionary new progressive lens geometry to that provided by ordinary progressive lenses.

REFERENCES

Ophthalmic progressive lenses generate space deformation, that is to say distortion of the objects seen through the lens. This is roughly due to power progression in the lens. The most common effect is known as “swim effect” sometimes reported by wearers in binocular and dynamic vision. It is commonly admitted that these effects are closely linked to the optical properties of the lenses (i.e. power and aberration repartition), thus establishing a necessary compromise with the fields of vision. The aim of this study was to find and validate experimentally different ways to design an ophthalmic progressive lens in order to minimize space deformation without compromising the field of vision.

We used a new method of optimization allowing to modify the lens shape while maintaining optical power and aberrations distribution.

We show that it is possible to manage space deformation thanks to the shape of the lens without modifying the power and aberrations distribution.

**Lens shape can be optimized to reduce “swim effect”**

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\Delta \alpha = \Delta x/\Delta P
\]

\[
R_d = (\Delta \alpha \Delta - \Delta \alpha \Delta_a)/\Delta \alpha \Delta
\]

The objective dynamic space deformation generated by a lens was expressed as the criteria \( \Delta \alpha \) which is the displacement \( \Delta x \) of vertical peripheral object lines divided by the power variation \( \Delta P \) along this lines.

This criteria is relative to the difference in apparent speed of the objects between the upper and lower part of the lens.

The gain \( R_d \) helps to evaluate the performance of lenses having the new optimized shape to reduce “swim effect”. It is about 20% compared to a front surface progressive lens, and even more depending on the prescription.

**Effect of lens shape on space deformation is perceived**

The experimental study shows that the subjects perceived differences in space deformation among the tested lenses. They mostly chose the lenses with the new shape (62%), compared to the classical ones (23%). In 15% of cases, they did not make a choice.

Among cases of choices (less dynamic space deformation perceived), 73% were in favor of the new type of lenses whereas 27% were for front surface progressive lenses.

**Conclusion**

In this study, we proved the importance of the geometrical shape of ophthalmic progressive lenses for space perception. Moreover we define a new way of optimizing these lenses. This study leads to the design of new types of progressive lenses having advanced shapes minimizing space deformation without compromising the field of vision.

**References**


