

AO Compact: A New Progressive Lens Designed For Small Frames

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Dr. Winthrop has been an ophthalmic lens designer for American Optical since 1967 and has become world renowned for innovative designs such as AO Pro, Truvision, Omni and now AO Compact. He has written numerous scholarly articles on lens design and has lectured throughout the United States and Europe.

Summary

As many dispensers know, the corridors of most progressive lenses are too long for today's fashionable small frames. Now, American Optical has introduced the first progressive lens designed specifically for small frames, the AO Compact. It has a 13 mm corridor that permits full reading function with a minimum frame depth of 17 mm. Yet it also retains the far and intermediate utility and comfort of a long-corridor progressive.

1. The need for a new progressive lens design

Most current progressive lenses were designed in an era of larger frames. According to the manufacturers, these designs typically require 22 mm minimum frame depth below the fitting cross. If the fitting cross of such a design is placed 4 mm above the equator of the frame, then the frame must have a B dimension of at least 36 mm to satisfy the 22 mm minimum depth requirement. But in many parts of the world—notably Europe and Asia—the B dimension of the average frame is 30-35 mm, and 25 mm is not uncommon. In the United States, smaller frames are becoming increasingly popular. This simple analysis suggests that yesterday's progressive lens designs may be incompatible with today's fashionable frames.

A consideration of the corridor length of the typical progressive lens leads to the same conclusion. Corridor length may reasonably be defined as the vertical drop from the fitting cross to the point of the corridor where the nominal add power, less one-eighth diopter, is attained. For example, in the case of a lens of nominal addition 2.00 diopters, the corridor length is the vertical drop from the fitting cross to the 1.875 diopter power point of the corridor. Such a definition accords with international standards on the addition power of multifocals. In terms of this definition, the industry average corridor length of currently available progressives is about 17 mm.

The 22 mm minimum frame depth requirement thus allows 5 mm depth of reading portion (or less if one subtracts the bevel), or about one pupil diameter. Clearly, if the average progressive is used in a small frame, that reduces this 5 mm depth even further, the reading function of the lens may be severely impaired. To illustrate, Figures 1 and 2 show, respectively, the surface mean power and astigmatism plots of a current progressive design having an addition of 2.00 diopters and a corridor length of 16.5 mm. This design is mounted with its fitting cross 4 mm above the equator of a frame having a B dimension of 30 mm and with a 4 mm inset. As shown in Figure 1, the reading portion, defined as the region bounded by the 1.875 diopter mean power line, is nearly edged off.

One is led to conclude, on the basis of corridor length, that currently available progressives are inappropriate for use in smaller frames. Of course, a manufacturer may attempt to make its product seem to have a shorter corridor by defining it differently. For example, corridor length is sometimes defined as the vertical drop from the fitting cross to the point at which 85% of the addition power is attained. But this is a misleading and optometrically unacceptable definition of corridor length. For instance, 85% of 2.00 diopters is 1.70 diopters, an entirely unacceptable reading addition if 2.00 diopters has been prescribed. It is misleading because, despite the promising definition, the true reading area may nevertheless be nearly edged off, as we saw in the example of Fig. 1.

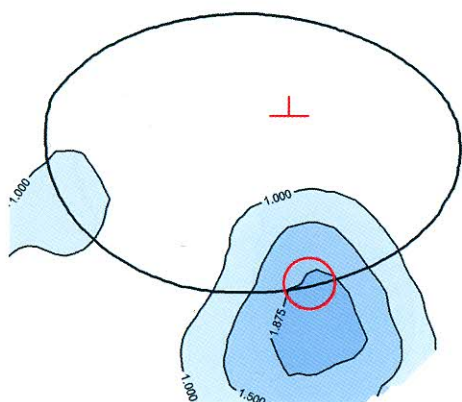


Figure 1

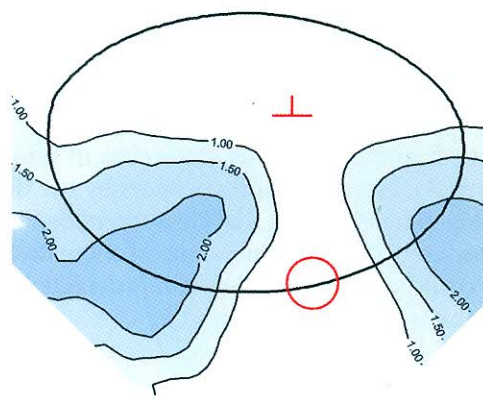


Figure 2

To cope with the very real problem of fitting current progressives into small frames, some dispensers may increase the addition power by 0.50 diopters above the value that would normally be prescribed. With this approach however, the patient is forced to read through the corridor itself rather than the designed reading portion, much of which may be edged off.

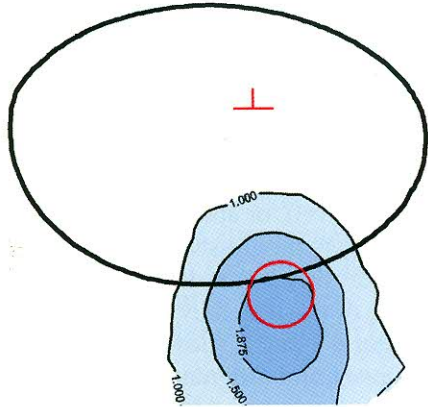


Figure 3

To illustrate, Figure 3 shows a current progressive having a 2.00 diopter addition and 18.0 mm corridor, its fitting cross located 4 mm above the equator of a frame having a B dimension of 30 mm. The reading portion is completely edged off. In Figure 4, the same design having a 2.50 diopter addition is shown, with the zone of prescribed power between 1.875 and 2.125 diopters highlighted. This effective reading portion offers only limited near vision utility.

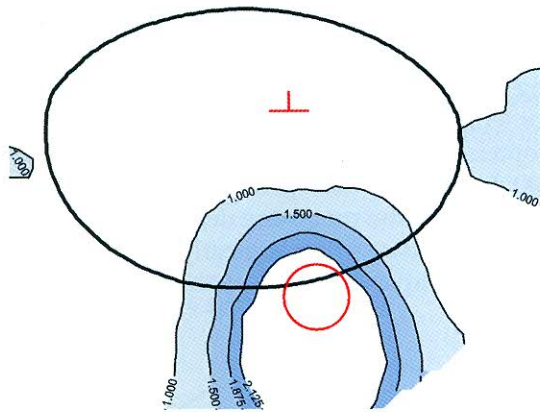


Figure 4

Finally, it may be said that some current progressives do have reasonably short corridors by the definition employed here, and on that basis might be thought suitable for use in small frames. One of these designs having a corridor length of 15.5 mm is depicted in the isocurve diagrams in Figures 5 and 6.

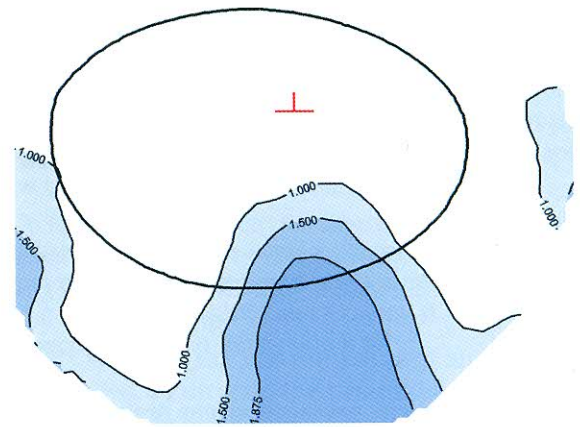


Figure 5

The fitting cross of this lens is located 4 mm above the equator of a frame having a B dimension of 30 mm. The mean power plot of Figure 5 shows a reading portion of 3.5 mm depth remaining within the frame after edging. This may provide adequate near vision utility for some patients.

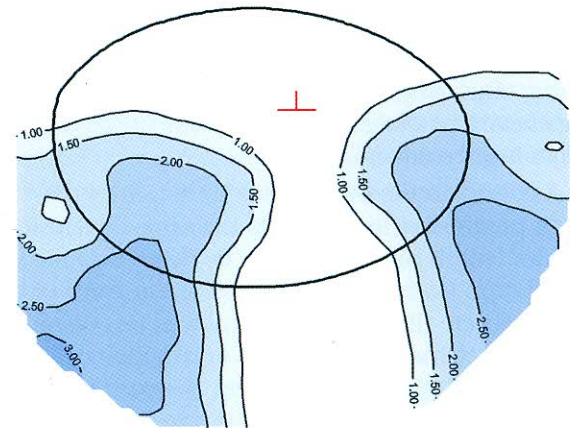


Figure 6

However, the astigmatism plot of Figure 6 reveals several undesirable features of the design. First, the magnitude of unwanted surface astigmatism is relatively strong, in excess of 2.50 diopters. These high values of surface astigmatism may lead to an unacceptable loss of acuity off axis. Second, the astigmatism on the temporal and nasal sides of the design are relatively unbalanced. The point is that a short corridor alone does not guarantee success in fitting small frames. Of equal importance is the utility and comfort of the overall design.

2. The AO Compact design

The preceding analysis of the corridor lengths and design characteristics of current progressive lenses points emphatically to the need for a new progressive, one specifically designed for small frames. The new AO Compact is such a design. The surface mean power and astigmatism characteristics of a 2.00 diopter addition AO Compact are shown in Figures 7 and 8. The main features of the design are described as follows.

2.1 Corridor length and reading field

As indicated in Table 1, the corridor length of the AO Compact (for additions below 2.50D) is 13 mm. This is about 2 mm shorter than the shortest corridor available in any other progressive design; and 4 mm shorter than the industry average. With AO Compact, a frame depth below the fitting cross of 17 mm is sufficient to provide full reading function. Corridor lengths for other additions are presented in Table 1. Wearer testing indicates that corridors shorter than these, while technically feasible, lead to an impairment of the intermediate-range utility of the lens. Also, shorter corridors are unforgiving of errors in fabrication and fitting.

Add (diopters)	Corridor length (mm)
1.00	13.0
1.50	13.0
2.00	13.0
2.50	13.9
3.00	14.5
3.50	15.1

Table 1 Corridor length of AO Compact (distance from the fitting cross to the point of nominal addition power, less one-eighth diopter).

The fitting cross of the lens of Figures 7 and 8 is located 4 mm above the equator of a frame having a B dimension of 30 mm. The mean power diagram of Figure 7 shows a reading zone depth of 5 mm remaining after edging. The improvement in near vision utility over that of the conventional designs depicted in Figures 1 and 5 is evident. Moreover, wearer trials show that the

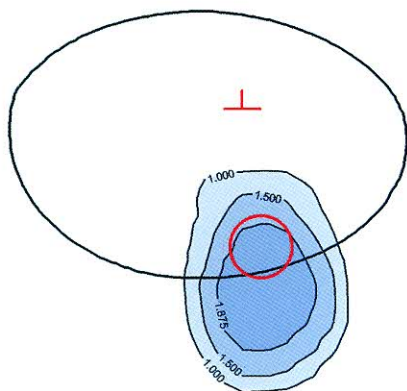


Figure 7

width of the near field of the AO Compact is adequate for reading a letter-size page of text. With few exceptions, most patients tested rank the near field of the AO Compact to be far superior to that of their current progressive mounted in the same small frame.

2.2 Far and intermediate fields of vision

The AO Compact features a unified design in which the conventional far and intermediate viewing zones blend imperceptibly into one another. It is the result of applying AO's proprietary Dirichlet smoothing procedure to the problem of progressive design for small frames. Wearing the AO Compact, one is unaware of any distinction or transition between distance and intermediate levels of the lens. In today's terminology the design is very soft. This feature is expressed in Figure 8 by the relatively wide spacing between the lines of constant astigmatism.

The feature of softness of the AO Compact at once translates into overall visual comfort, marked by an absence of swimming effects. As a consequence, for most patients, adaptation to the design is immediate.

One also sees from Figure 8 that the overall level of unwanted surface astigmatism contained within a typical small frame is substantially lower than that of other progressives. In contrast to most rival designs, the surface astigmatism of AO Compact actually decreases towards the lateral intermediate peripheries of the lens. As a result, wearers of the AO Compact report far greater image clarity at intermediate distances, centrally and peripherally, than that provided by competing progressives fit in the same frame. The sensation reported is one of relative openness and lack of restriction of the visual field.

This sensation of openness extends also to the level of far vision. Virtually all patients find the distance vision provided by the AO Compact to be equivalent to or better than that of competing progressives fit in the same small frame.

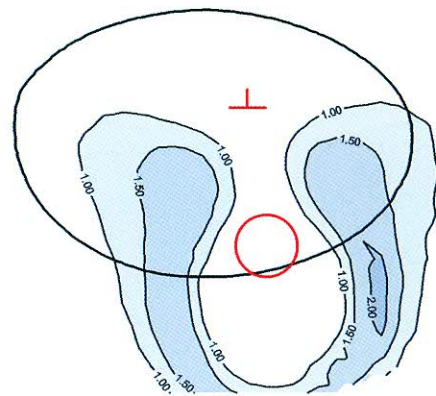


Figure 8

2.3 Balanced Optics

From Figures 7 and 8 one sees that the power and astigmatism distributions of AO Compact are evenly balanced between nasal and temporal sides of the lens. At the same time, the AO Compact is sufficiently asymmetrical about the corridor meridian to render negligible any vertical prism imbalance between the lens pair. As a consequence of these design features, the AO Compact provides superior performance.

2.4 Multi-design

Above 2.00 diopter addition the design of AO Compact changes gradually with add to ensure consistent far, intermediate and near vision performance throughout the add range. Below 2.00 diopter addition the form of the design is approximately independent of add; for in this lower add range, the design of each add, being proportional to that of the 2.00 add design, is already optimized and multi-design is unnecessary.

2.5 Variable inset

It is known that the required inset of the reading portion of a progressive multifocal depends on the degree of ametropia. To ensure that the monocular reading fields fully overlap, the inset of the reading field of the AO Compact varies with base. Average insets are shown in Table 2.

Base	Prescription Range	Average inset each eye
1	-9.00 to -5.25	2.1 mm
3	-5.00 to -0.75	2.5 mm
5	-0.50 to +2.00	2.5 mm
7	+2.25 to +5.00	2.8 mm

Table 2 Average inset (in millimeters per eye) of the reading portion of AO Compact as a function of prescription range.

**Contour plots depict progressive lens samples with a plano distance and either 2.00 or 2.50 diopter addition as referenced in the text.*

3. Conclusion

The AO Compact is a unique new lens designed specifically for small frames. Its progressive corridor for 2.00 diopter addition is about 4 mm shorter than the industry average, permitting a minimum frame depth below the fitting cross of 17 mm.

In the small frame environment the AO Compact performs admirably, providing a much more usable reading field than competing designs, a fact substantiated by wearer testing.

With AO Compact it is unnecessary, and not recommended, to increase the addition power above that normally prescribed. To achieve the full benefit of this lens only the minimum addition power consistent with the patient's near vision needs should be prescribed. Perhaps unexpectedly, as judged by wearers, the AO Compact outperforms competing designs not only in the reading function, but in other aspects as well: far and intermediate utility, freedom from distortion, overall comfort and time of adaptation. It is emphasized that the design of the AO Compact is not simply a scale-reduced version of a conventional progressive design. Rather it is a special design in which the inevitable lateral progressive aberrations have been distributed in a manner to make them as unobtrusive as possible within the confines of a small frame. In this light it is not surprising that AO Compact is generally preferred to competing progressives on all counts.

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