Progressive addition lenses: Comparison of designs according to the visual fields they provide without astigmatic aberrations for far near and intermediate vision

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Abstract

Objective: In this study the optical behavior of various deigns of progressive addition lenses were measured and analyzed. The goal was to provide information on the various designs of progressive addition lenses in order to enable professional opticians - optometrists to choose from different designs based on individual requirements for each user. **Method and materials:** The optical properties of 12 different designs of progressive addition lenses having the same power but different design were measured by means of an auto-focimeter. (TOMEY TL-100) specially modified for such specialized measurements. The lenses were fabricated having plano power (0.00 Ds) for distance vision and Addition +2.00 Ds diopters. The magnitude of unwanted astigmatism and the width of clear vision (having ≤ 0.50 Dc of unwanted astigmatism) in the areas of distant, intermediate and near vision were calculated for these designs. **Results:** The optical characteristics of the designs measured were significantly different. The differences were significant as to the reference sizes and widths of clear vision for far, near and intermediate, the amount of unwanted astigmatism, and the minimum mounting height on the spectacle frame.

Key words: progressive addition lenses, deigns, power.

Introduction

The use of progressive addition lenses has grown steadily since its initial introduction to the market. Approximately 85% of presbyopians during this last period prefer the use of progressive addition lenses.[1-2] Studies have shown that a large percentage of users prefer progressive addition lenses compared to bifocals.[2-4]

The progressive addition lenses optical characteristics are complex and vary from design to design. Theoretically, there may be an infinite number of progressive addition lenses designs. One feature, however that any design of progressive addition lenses present is the appearance of unwanted astigmatism in the periphery of the lens (usually situated in the lower diagonal locations from the central axis of the lens, the umbilical meridian of the lens).[1, 4]

Despite the great diversity among progressive addition lenses designs , the optical information provided to professional opticians - optometrists mainly confined in information given by the manufacturer who recommends where the lens should be placed in front of the pupil of the wearer (cross positioning), positions on the lens in which the distance and near prescription can be checked (horseshoe and circle) , and the straight line where the lens should be placed relative to the reference line (datum line) of the form of the selected frame. The manufacturers also provide a recommended minimum mounting height where the cross of the lens should be placed from the bottom of the frame. But there is no definite instruction on which is the minimum mounting height of the cross that is associated with progressive addition lenses visual behavior for satisfactory near vision.

The most recent clinical studies on the optical characteristics of progressive addition lenses was in 1989 1991.[1-3] The progressive addition lenses designs now available on the market have almost completely changed since then, even thought those studies included only contour plots[1-6] of the lens unwanted astigmatism and the spherical progression on the lens surface and did not analyze the different zones of vision.
Table 1 presents the data given by the manufacturers for their designs of progressive addition lenses measured in this study. The lenses were selected so as to include as much as possible the most common currently available lenses. However, due to the large number of designs available in the market today, the list of included lenses in this study is certainly not complete.

TABLE 1.	PAL brand name	Distance of the fitting cross from the markings	Distance of the power for far from the markings	Minimum fitting height from the cross
1	AO b'Active	2	5,5	18
2	AO Compact	2	5,5	15
3	AO ProEasy	2	5	18
4	Hoya Summit CD	4	8	14
5	Hoya Summit Pro	4	6	18
6	Hoya Wide	4	8	18
7	Rodenstock Life free	4	6	18
8	Rodenstock Life fee XS	4	6	14
9	Solamax	4	10	17
10	Varilux Comfort New editition	4	8	17
11	Varilux Ideal	4	8	17
12	Zeiss Gradal Top	6	9	18

Table 1. *The 12 different deigns of progressive addition lenses measured in this study and the data provided by the manufacturers.*

All lenses were measured with reference to the line of engraved signs (signs that are 34 mm apart and represent the line 0-180 of the lens) and the lenses were properly aligned in the modified focimeter. The lenses had 0.00 distance vision prescription and Addition 2.00. Starting from the fitting cross the lenses were measured. The vertical and horizontal displacement was 1.00 mm and each time was achieved with a specially adapted vernier to the automatic focimeter. The measurement limits set for clear distance vision was 0.25 Ds for the spherical component for the distance vision area and for the cylindrical component was 0.50 Dc. The measurement limits set for clear near vision was 1.75 to 2.00 Ds for the spherical component and for the cylindrical component was 0.50 Dc. The measurement limits set for clear intermediate vision was 0.75 to 1.00 Ds for the spherical and for the cylindrical component was 0.50 Dc. The intermediate vision area was measured in the middle distance between the fitting cross and the circle for near vision.

Results for the distance vision zone

The width for clear distance vision was measured at the cross (which is placed in front of the eye pupil). The width measured in this region was horizontally and vertically in 1 mm step and it represents the range of vision when the user is looking straight ahead.

Figure 1 shows the total width in mm^2 for each progressive addition lens design measured. The lenses are sorted according to the distance vision zone width at the level of the fitting cross and presented in decreasing order, so that larger areas to be on top.

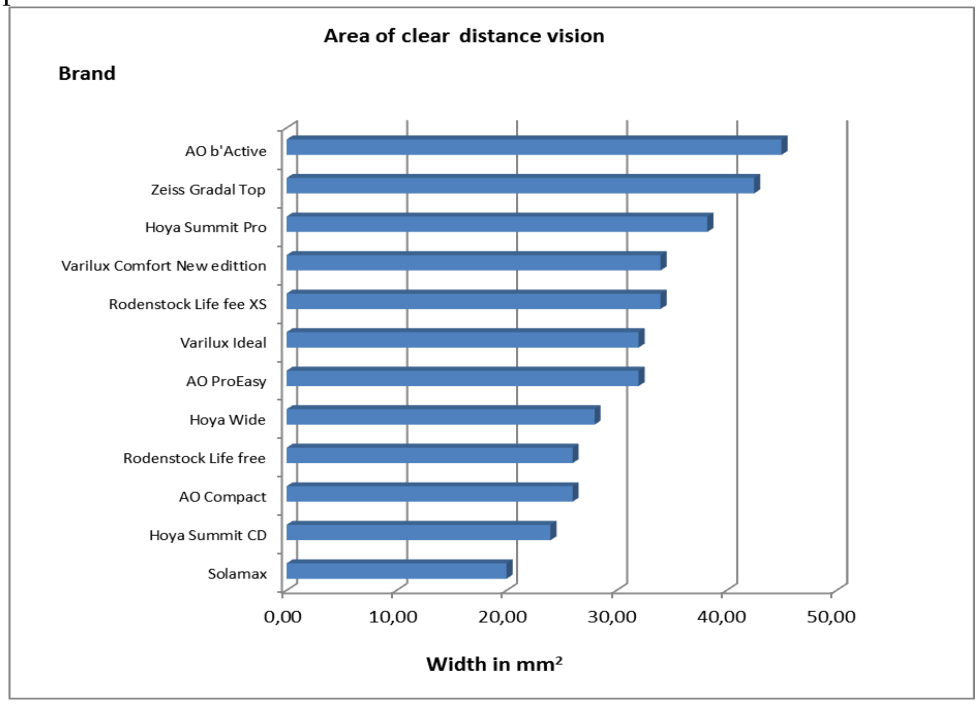

Figure 1. *Lenses are sorted according to the distance vision zone width of clear vision in mm^2 and presented in decreasing order, so that larger areas to be on top.*

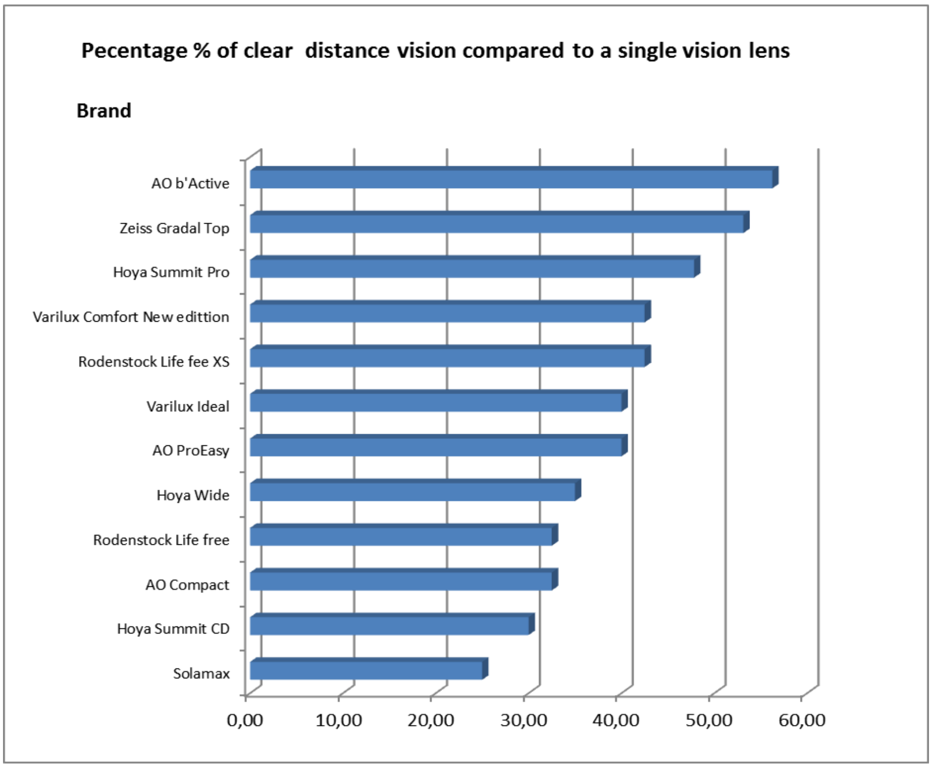

Figure 2. *Lenses are sorted according to the percentage coverage of distant clear vision and presented in decreasing order, so that the designs with the best rate to be on top.*

Since 1 mm on the surface of the lens represents 2° of visual field (this assumes vertex distance 14 mm and 15 mm distance from the apex of cornea to the center of rotation of the eye), the lateral field of vision in a single vision lens corresponds to 40° temporal and 40° nasal so that the total field of vision is 80° wide. Since the wearer of progressive addition lenses due to astigmatic aberrations has to move his head in order to have good vision in lateral gaze we assume that half of the 80° is covered by the head move and the rest is covered by the eye move. On this assumption the coverage rate of good distance vision for each design compared to a single vision lens is shown in Figure 2.

Results for the intermediate vision zone

The width of the intermediate vision zone was measured at the level where a corresponding addition +0,75 +1,00 Ds was found comprising 50% of the total strength of the addition +2,00 Ds. The width measured in this horizontal area because it represents the range of vision when the user is looking straight ahead in a computer display. Figure 3 shows this range for each measured progressive addition lens design.

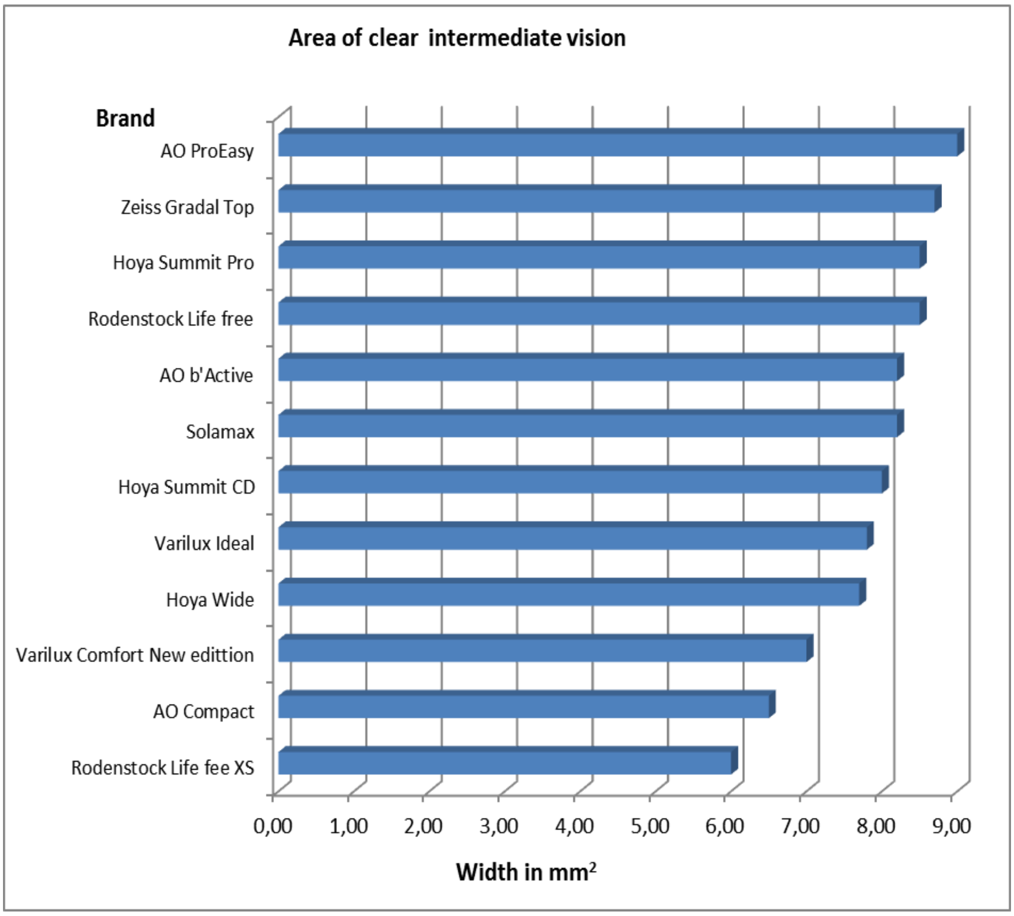

Figure 3. *Lenses are sorted according to the intermediate vision zone width of clear vision in mm² and presented in decreasing order, so that larger areas to be on top.*

The evaluation of these designs as to the intermediate vision field had as criterion the range of vision of a single vision lens when there is a computer screen at approximately 60 mm distance from the user. The total angle needed to clearly see a display of 19 inch is about 35° for this distance. Thus the overall surface of clear vision of the lens should be about 17.5 mm. On this assumption the coverage for a good intermediate vision for each design is shown in Figure 4.

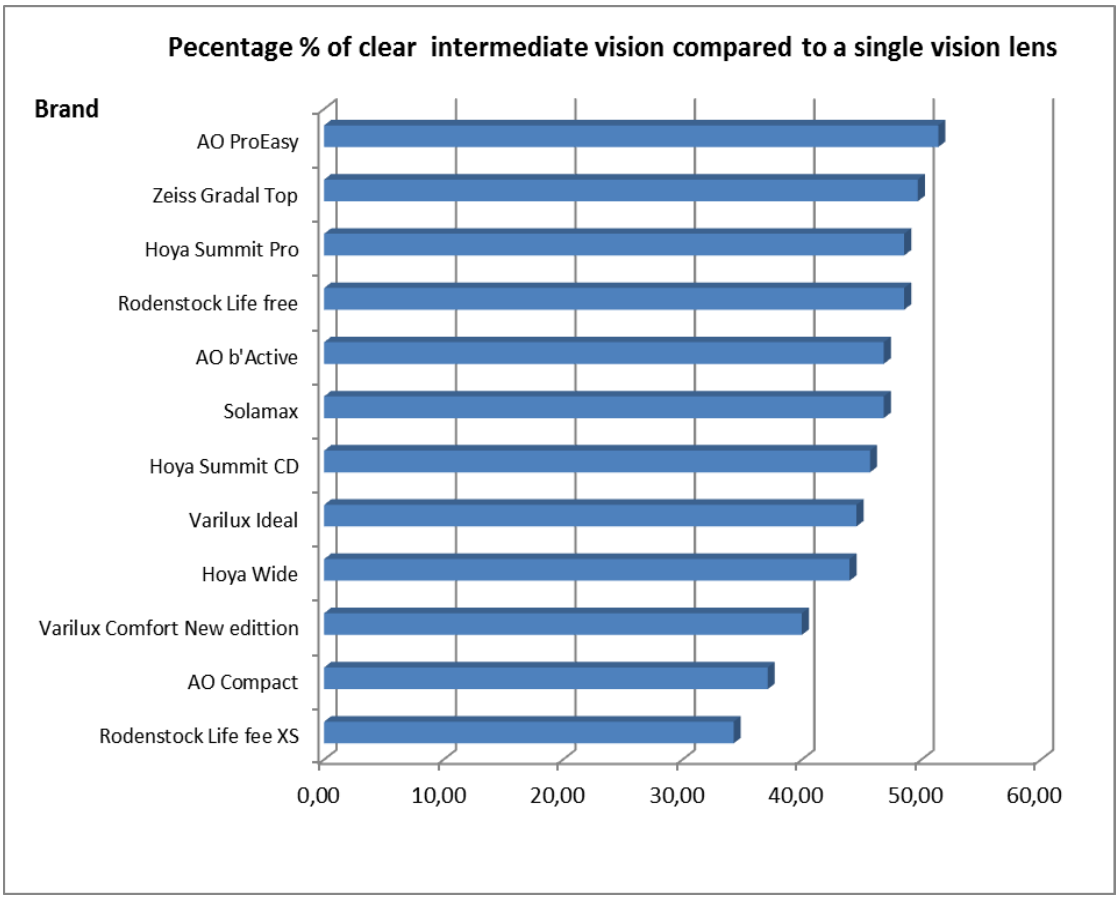

Figure 4. *Lenses are sorted according to the percentage coverage of intermediate clear vision and presented in decreasing order, so that the designs with the best rate to be on top.*

Results for the near vision zone

The width of near vision was measured at the circle for near vision for each design. At this point the addition depending on the design of the progressive addition lens reached between +1,75 Ds and +2.00 Ds addition The width measured in the horizontal range of each respective design in order to find the range of clear vision when the user looks at a near point. Figure 5 shows the width for each measured progressive addition lens design.

The evaluation of these designs as to the near vision field had as criterion the range of vision of a single vision lens when the user observes one A4 page at approximately 33 mm distance from the user. The total angle needed to clearly see is approximately 30° for this distance. Thus the overall surface of the lens of clear vision should be about 15 mm. On this assumption the coverage for a good near vision for each design is shown in Figure 6.

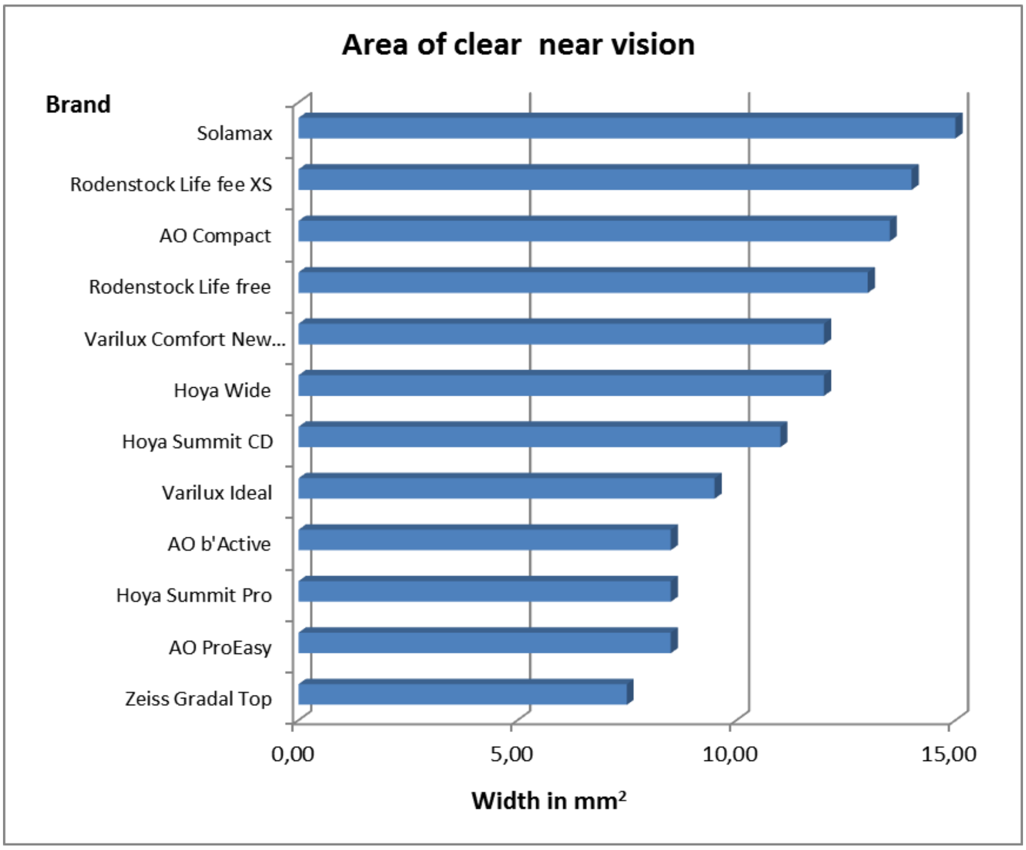

Figure 5. *Lenses are sorted according to the near vision zone width of clear vision in mm^2 and presented in decreasing order, so that larger areas to be on top.*

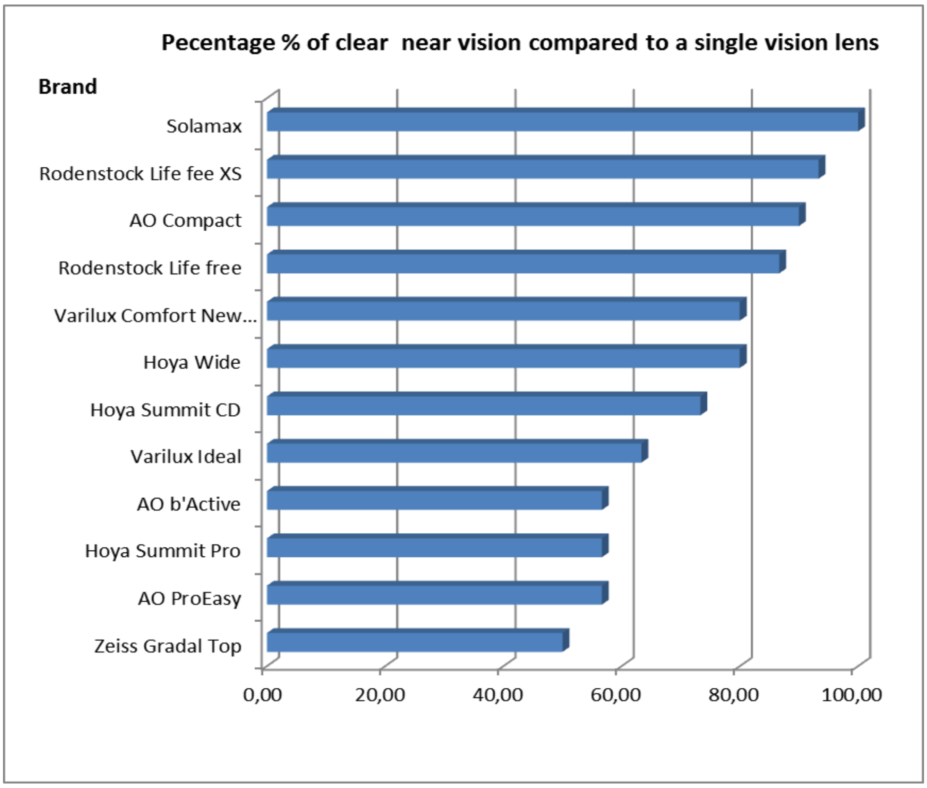

Figure 6. *Lenses are sorted according to the percentage coverage of near clear vision and presented in decreasing order, so that the designs with the best rate to be on top.*

Unwanted astigmatism

The highest magnitude of unwanted astigmatism for each lens design is shown in Figure 7. All progressive addition lenses present unwanted astigmatism bilateral of the umbilical meridian of the lens. The magnitude of this astigmatism depends on the design of the lens and the length of the umbilical corridor.

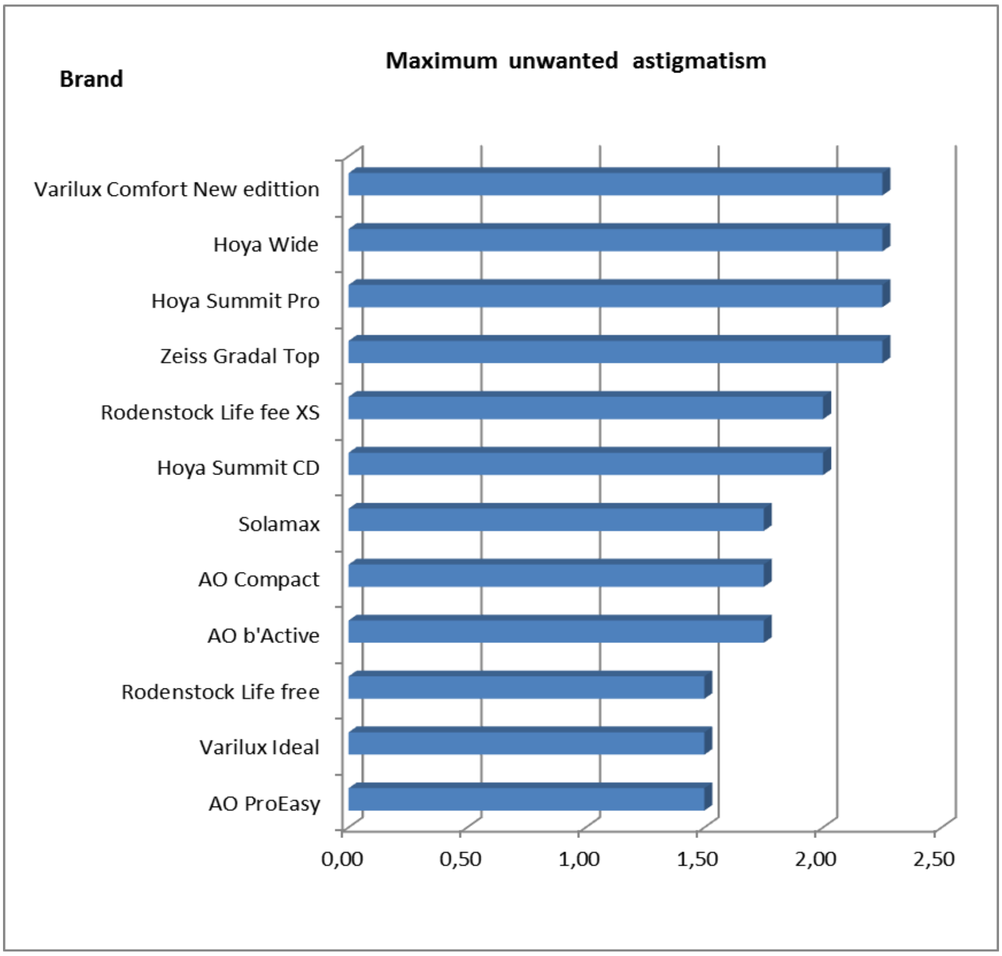

Figure 7. *Lenses are sorted according to the lowest to the highest magnitude of unwanted astigmatism, and are presented in decreasing numbers, so the design with the smallest degree of unwanted astigmatism to be on the bottom.*

Conclusions

Large variations and differences that exist in the optical properties of different progressive addition lens designs show that there is not a single design model that fully meets the needs of users. Measurements and analysis clearly showed that some designs provide better zones for distance vision, some for intermediate vision and some for near vision, or have reduced unwanted astigmatism. The sizes of each zone and the areas that provide clear vision proved to be less than the requirements that users need.

The results and analysis presented in this study, although based on some assumptions, can be used to choose among the various progressive addition lens designs to meet specific visual needs for the users. It is also expected that the findings presented in this study will serve as a stimulus for further research in ophthalmic lens industry to develop newer designs for more specific needs for different users. Of course it must be stressed that the best criterion for choosing the right progressive addition lens design is based on clinical studies where users are using different types of progressive addition lens designs for some time and so more subjective characteristic of each design can be concluded.

References

1. Cho MH, Barnette CB, Aiken B, Shipp M. "A clinical study of patient acceptance and satisfaction of Varilux Plus and Varilux Infinity lenses." J Am Optom Assoc 1991;62:449–53.
2. Sullivan CM, Fowler CW. "Analysis of a progressive addition lens population." Ophthalmic Physiol Opt 1989;9:163–70.
3. Gresset J. "Subjective evaluation of a new multi-design progressive lens." J Am Optom Assoc 1991;62:691–8.
4. Minkwitz G. "On the surface astigmatism of a fixed symmetrical aspheric surface." Opt Acta (Lond) 1963;10:223–7.
5. Charman WN. "Theoretical aspects of concentric varifocal lenses." Ophthalmic Physiol Opt 1982;2:75–86.
6. Simonet P, Papineau Y, Lapointe R. "Peripheral power variations in progressive addition lenses." Am J Optom Physiol Opt 1986;63: 873–80.