Progressive addition lenses: analysis of the power of induced astigmatism

Lentes progressivas: análise da potência do astigmatismo induzido

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ABSTRACT

Objective: *Evaluate induced astigmatism in progressive addition lenses into deflectometer measurements.* ***Methods:*** *Eleven progressive addition lenses were included with power away from +1.00D and addition 2.00D. Induced astigmatism was assessed twelve points in the zone intermediate, with six on each side of the progressive corridor in deflectometer.****Results:*** *There are significant differences between the sums of induced astigmatism on each side of the corridor and in the general in progressive addition lenses studied, with coefficient of variation with strong dispersion (CV 10-13%).* ***Conclusion:*** *There is an important variation of the power of induced astigmatism in progressive addition lenses.*

Keywords: *Refraction; ophthalmic lens, Progressive addition lenses; Optics: Presbyopia; Equipment and supplies; Brazil*

RESUMO

Objetivo: Avaliar a potência do astigmatismo induzido nas lentes progressivas em um deflexômetro. **Métodos:** Foram incluídas onze lentes progressivas com poder longe de +1,00D e adição 2,00D para perto. Avaliou-se o astigmatismo induzido em doze pontos do campo intermediário, sendo seis de cada lado do corredor progressivo no deflexômetro. **Resultados:** Existem diferenças significativas entre as somas dos astigmatismos induzidos de cada lado do corredor progressivo e no total geral nestas lentes estudadas, com coeficiente de variação com forte dispersão (CV 10 a 13%). **Conclusão:** Existe uma variação importante das potências dos astigmatismos induzidos nas lentes progressivas.

Descritores: Refração; Lentes oftálmicas; Lentes progressivas; Óptica; Presbiopia; Equipamentos e provisões; Brasil.

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Introduction

Presbyopia is present in most patients in the fifth decade of life and is a natural reduction of accommodative ability[1]. The use of progressive lenses (PLs) is very common in the treatment of presbyopia in patients with refractive errors[2].

PLs have evolved considerably in the past 30 years, but all of them still have areas with aberrations around the progression corridor, called induced astigmatism (IA). IA varies in degree and distribution and is directly proportional to the increase in addition and inversely proportional to the length of the corridor for the same model of lenses[3,4]. There are several manufacturers of PLs, and about 140 models are available in Brazil; however, little technical information on IA is available to ophthalmologists and opticians. There are few studies on this topic in the literature, most of which are subjective studies based on patient satisfaction[5].

This study assessed PLs with a +2.00 D addition using a lens mapper (Rotlex Class Plus). The power (Cylindrical Dioptric Power, D Cyl) of induced astigmatism was assessed at specific sites in the lenses.

The aim of this study was to assess differences in the power of induced astigmatism caused by some progressive addition lenses available in Brazil.

Methods

Eleven types of PLs from different manufacturers were selected, with powers of +1.00 D for far vision and an addition of 2.00 D for near vision (Annex 1). All PLs included in the study were right eye surfaced resin lenses. They were chosen according to their availability in our region (Mato Grosso, Brazil) and their minimum fitting height.

The authors analysed the PLs using the Rotlex Class Plus lens mapper developed by Rotlex (1994, Israel). This instrument detects, in a few seconds, all the dioptric measures of a lens in a single measurement. This is a Moire-type lens mapper, which uses a diverging laser source to analyse the lenses. The beams refracted by the lens go through two grids and form a pattern (Moire) in a diffusing screen, which is captured to generate maps of spherical and cylindrical power and axis in each millimetre of the lens (Figure 1).

The lenses were centred based on their permanent remarking sites. The digital files corresponding to the eleven PLs were examined using Rotlex's analysis software based on the measurements taken at twelve sites lateral to the progressive corridor, six on each side. Laterally, these sites were located at a distance of 5 and 10 mm from a midline between the fitting cross and the central point of the near field, at the minimum fitting height given by each manufacturer. Vertically, the measurement sites were located 3, 7 and 11 mm below the cross. Each measurement site had a radius of 0.5 mm. A schematic drawing of these sites is shown in Figure 2.

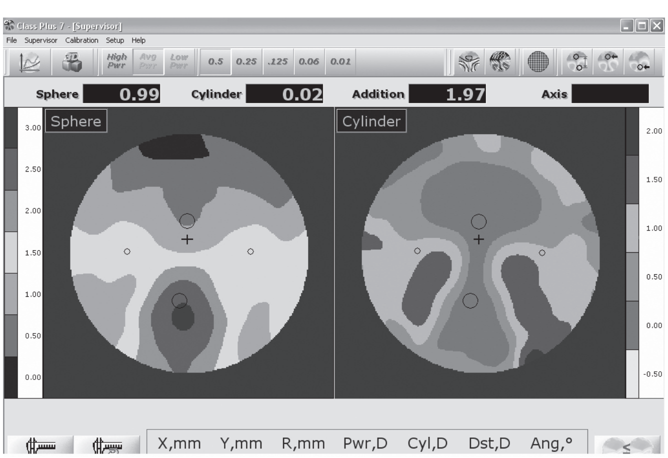


Figure 1: Lens mapping, with sphere mapping to the left and cylinder mapping to the right

Table 1

Sums of measurement sites for IA power

Groups of sites	Sites and IA sums
Nasal sum 1	N1 + N3 + N5
Nasal sum 2	N2 + N4 + N6
Temporal sum 1	T1 + T3 + T5
Temporal sum 2	T2 + T4 + T6
Nasal total	Nasal sum 1 + Nasal sum 2
Temporal total	STemporal sum 1 + Temporal sum 2
3 mm row total	N1 + N2 + T2 + T1
11 mm row total	N5 + N6 + T6 + T5
Grand total	Nasal total + Temporal total

The values found for the twelve sites were grouped in Table 1.

To determine the height of the progression corridor we measured the spherical power from the fitting cross until the near field. The beginning of the corridor was considered as the point where the power reached 0.25 D, and the end where it reached 1.75 D.

For data analysis we adopted a significance level of 5 % (á = 0.05), corresponding to a probability of error (p) d" 0.05, a value considered statistically significant. We used the nonparametric Wilcoxon Signed Ranks Test to compare the sums. Statistically significant differences were found between sums 1 and 2 on both sides and between the sums of the rows located at heights of 3 and 11 mm. No statistical difference was found between the nasal and temporal totals. Microsoft Excel 2000 software was used in the study.

This study was approved by the Research Ethics Committee of the General University Hospital under registration UNIC – 2011/048.

Results

The results of the analysis of the 11 PLs are shown in Table 2, and Table 3 shows the descriptive statistics.

Chart 1 shows the distribution of PLs as regards the nasal, temporal and grand total values of IA power.

Chart 2 shows a weak negative linear trend between the height of the corridor and the grand total IA.

Chart 3 shows a strong positive linear trend between the grand total IA and the IA sum of the row located 3 mm below the fitting cross.

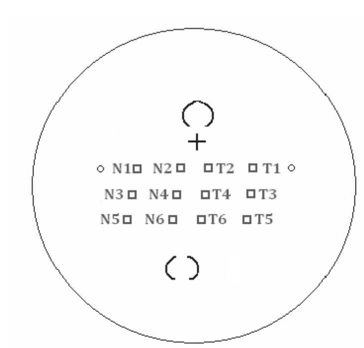


Figure 2: Locations of the 12 measurement sites for IA power (squares)

Table 2

IA sums and heights of progressive corridors as captured in lens mapping

Progressive lens	Nasal sum 1	Nasal sum 2	Temp sum 2	Temp sum 1	Total nasal sum	Total temp sum	Grand Total	Sum at 3 mm row	Sum at 11mm row	Height of progressive corridor (in mm)
A	4,77	2,60	3,49	5,18	7,37	8,67	16,04	4,32	5,86	14
B	3,97	2,66	2,94	4,20	6,63	7,14	13,77	3,33	5,52	13
C	5,80	3,58	3,30	5,16	9,38	8,46	17,84	4,98	6,60	10
D	4,44	2,91	2,42	4,08	7,35	6,50	13,85	3,83	5,20	14
E	5,38	3,13	3,83	5,40	8,51	9,23	17,74	4,60	6,67	13
F	4,71	3,48	3,65	5,03	8,19	8,68	16,87	4,65	6,06	12
G	4,83	3,16	3,48	4,98	7,99	8,46	16,45	4,78	5,40	12
H	4,60	2,70	3,49	5,00	7,30	8,49	15,79	4,07	5,95	12
I	3,71	2,59	3,01	3,87	6,30	6,88	13,18	3,47	4,84	12
J	4,68	3,04	3,73	5,06	7,72	8,79	16,51	4,80	5,63	10
L	4,34	2,77	3,27	4,61	7,11	7,88	14,99	3,92	5,71	13

Note: IA sums are shown in cylindrical dioptres.

Table 3

Estatísticas descritivas dos dados coletados

Progressive lens	Nasal sum 1	Nasal sum 2	Temp sum 2	Temp sum 1	Total nasal sum	Total temp sum	Grand Total	Sum at 3mm row	Sum at 11mm row	Height of progressive corridor (in mm)
Mean	4,66	2,97	3,33	4,78	7,62	8,11	15,73	4,25	5,77	12,27
Median	4,68	2,91	3,48	5,00	7,37	8,46	16,04	4,32	5,71	12,00
Standard deviation	0,58	0,35	0,41	0,51	0,87	0,89	1,60	0,56	0,55	1,35
Coefficient of variation	13%	12%	12%	11%	11%	11%	10%	13%	10%	11%

Discussion

PLs are characterised by a gradual and continuous increase in spherical power until it reaches the desired addition, without visible demarcation lines. The optical and cosmetic advantages of PLs have been known for many decades, and the aesthetic aspect has been increasingly requested by patients. However, for a gradual increase to be achieved, a change in curvature in one of the surfaces is required, which leads to induced astigmatism laterally to the progressive corridor. All manufacturers in the industry have been making efforts to decrease IA, with project designs being kept secret for obvious business reasons.

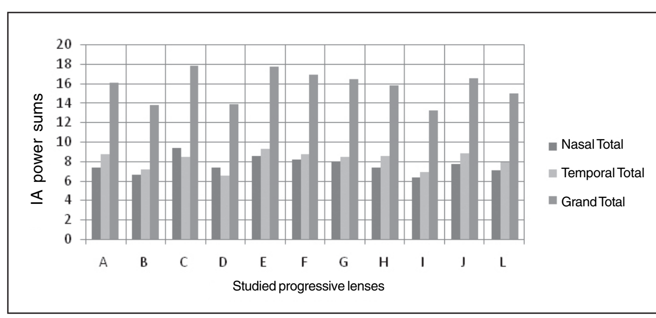
IA is different from the astigmatic aberrations seen in spherical lenses when light rays cross obliquely to their main axis. Users of PLs may present different complaints related to IA, such as distortion, blurring, and/or floating image, which can be related to IA axis, IA power, and variation in IA power or in the binocular balance of spherical and cylindrical power, respectively[6].

This study shows the differences in IA power between the studied lens sites and between different lenses, as shown in Tables 2 and 3 and Chart 1; the differences shown are statistically significant. The coefficient of variation (CV 10 %) of the grand total IA clearly demonstrates this fact.

In Chart 2, the weak negative linear trend (0.19) between the grand total IA and the height of the progression corridor shows the intense work of manufacturers in reducing IA without increasing the corridor height to the same degree. This is in contrast with concepts found in studies with PLs which relate corridor height to the area of the intermediate field[7], with a strong positive linear correlation between them. However, the

Chart 1

Distribution of PLs based on IA power in the nasal and temporal fields and grand total (in cylindrical dioptres)



two PLs with the smallest corridors (10 mm) were among those with the highest grand total IA powers (PLs **C**: 17.84 and **J**: 16.51 D Cyl). These PLs should be fitted in frames with small vertical size. By contrast, PLs **A** and **D**, which had the largest progression corridors (14 mm), did not have the lowest IA power.

Chart 3 shows a strong positive linear trend (0.86) between the grand total IA and the IA sum of the row located 3 mm below the fitting cross, clearly showing that a smoother onset of progression leads to a lower total IA.

The high number of PL designs currently available in Brazil and the world and the little technical information about them make it difficult to prescribe PLs; however, new PLs with medium corridors and a minimum fitting height around 17 mm, when fitted

Chart 2

Dispersion chart relating the grand total of IA sums to the height of the progressive corridor

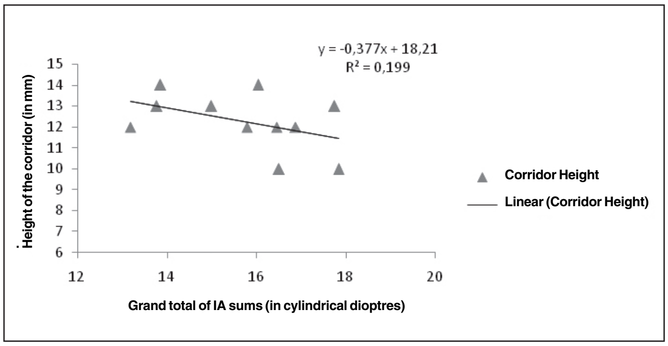
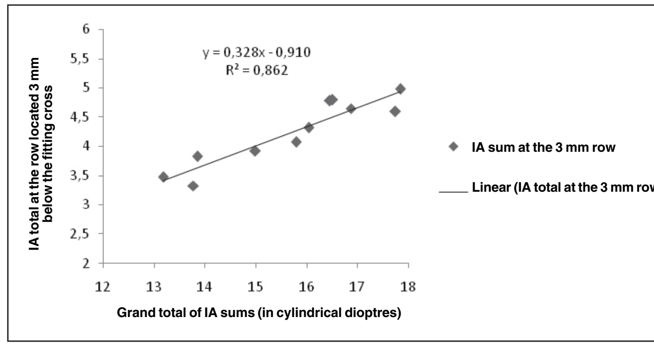


Chart 3

Dispersion chart relating the grand total of IA sums to the sum at the 3 mm row



Annex 1

Studied progressive lenses and their manufacturers

Studied lenses	Name of PL	Manufacturer
A	Espace Selective	Brasilor
B	Gradal Top	Zeiss
C	Multivis Ampla	Multivis
D	Multivis Extra	Multivis
E	Sapphire LP	Segment
F	Sola Elan	Zeiss
G	Solamax	Zeiss
H	Varilux Comfort	Essilor
I	Varilux Physio	Essilor
J	Varilux Pix	Essilor
L	Zeiss GT2	Zeiss

at this height, make the near field's area smaller at the studied addition, as previously shown in the literature[7].

The classification of PLs as hard or soft lenses is not very useful for PLs, as they are a middle term between the two types and should only be considered as softer or harder. It should also be emphasised that many current PL models are offered with different designs with varying additions (Multi Design - softer lenses with lower additions, harder lenses with higher additions)[5]. They also have larger vertical corridor sizes with increasing addition, however with disproportionate increases between each of them, showing that this analysis can not be extended to all available additions in every PL. Another issue to consider is Minkwitz theorem, which shows, in a simplified manner, that higher additions lead to higher IA for the same lens design[4].

Myopic or emmetropic patients who will use PLs for the first time or those requiring a large field of far vision (e.g., truck drivers) should be prescribed lenses where the progressive corridor starts as far as possible from the fitting cross and with the lowest possible IA, which in this study were PLs **B**, **I**, **D,** and **L**. This will probably facilitate adaptation to PLs.

It is important to note that only one aspect related to PLs was studied here, and other important factors may also affect tolerance to different designs, such as IA axis, the size of low IA fields (<0.50 D), second-order aberrations, binocular balance, and prismatic induction, among others.

Conclusion

There is clearly a large number of PL designs, with significant variations in IA power and therefore in the size of intermediate and near fields. Therefore, appropriate prescription of PLs is important to increase patient satisfaction.

For a better understanding of PLs available in Brazil, further studies are needed that asses other variables such as the ones mentioned here.

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Note: Other national and international companies were contacted but showed no interest in participating in the study.

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