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Quality of vision with presbyopic contact lens correction: subjective and light sensitivity rating

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Abstract *Purpose*: To quantify the quality of vision achieved with multifocal and bifocal contact lenses. *Methods*: We analyzed differential light sensitivity by computerized automatic perimetry in 21 patients wearing monofocal soft contact lenses (group 1, controls) and multifocal and bifocal contact lenses (groups 2 and 3, respectively). Seven patients each were fitted with multifocal or bifocal contact lenses; seven patients were without contact lenses (without correction for testing the visual periphery and with near-vision correction using monofocal contact lens for testing the central 30 degrees of vision). The type of correction was randomly changed in a crossover fashion so that each eye was examined at different times with different corrections. Humphrey 640 VFA computerized automated perimetry was used to test visual fields at baseline, 45 days, and 3, 4.5, and 6 months. *Results*: A statistically significant difference was found between the global sensitivities (GS) of the central visual field in patients with near-vision monofocal contact lenses and with bifocal contact lenses (P=0.0273) and between the GS of the central visual fields with multifocal contact lenses and with bifocal contact lenses (P=0.0261). In both cases, the GS were significantly reduced with bifocal contact lenses (total GS: group 1, 11256 dB (Decibels); group 2, 11154 dB; group 3, 10679 dB). *Conclusions*: The results indicate that there is reduced differential light sensitivity in the central 30 deg of the visual field with bifocal contact lenses compared with multifocal contact lenses and monofocal contact lenses (controls).

Introduction

Patients with presbyopia may not welcome spectacle correction for near vision, because it requires removing and putting on spectacles, depending on the vision required, and because it is a sign of aging [8]. Patients may not adapt to correction with multifocal spectacle lenses because they cannot achieve excellent near vision for long periods [4]; multifocal spectacle lenses also cause problems associated with the progression channel (e.g., astigmatic aberration of the lenses in their lateral sectors with consequent difficulties during some daily activities, such as reversing the direction of a motor vehicle) [13, 15].

To partially reduce these problems, contact lenses recently have been designed that allow simultaneous correction of presbyopia and ametropia, i.e., multifocal and bifocal contact lenses. The new lenses have a different design than the preceding generations of bifocal and multifocal contact lenses [2, 11, 12, 20].

Because the new generation of lenses have a peculiar optical geometry, we wanted to determine whether the potential benefits were invalidated by a reduction of the patients' quality of vision. Therefore, to evaluate the quality of vision with multifocal and bifocal contact lenses, we evaluated the differential light sensitivity by means of static threshold automatic perimetry [19], performed with the patients wearing such contact lenses.

Perimetry is a well-standardized method of testing that provides data suitable for comparison and statistical analysis [5].

Material and methods

Thirty patients with presbyopia were enrolled in this study. The final sample consisted of 21 patients. The 16 women and 5 men ranged in age from 45 to 55 years (mean 50.2 years) (Table 1).

All patients met the following criteria: the presence of presbyopia alone or associated with ametropia (myopia, –0.50 to –6.00 D; hyperopia, +0.50 to +4.00 D); astigmatism ≤1.00 D; absence of ocular or systemic diseases, such as glaucoma, retinopathy, optic neuropathy, or central nervous system disease, that could affect the perimetry; no previous ocular surgery; no ocular or orbital trauma within 3 months of the start of the study; no current ocular surface disorders; good tear film (break-up time >15 s, Schirmer I test >10 mm/5 min [1], and regular black line [17]); no use of topical and systemic drugs, such as beta-blockers, diuretics, hormones, antidepressants, and antispasmodic hypnotics, that can modify tear secretion or of topical agents, such as antibiotics, antivirals, astringents, or chronic use of preserved collyrium, that can damage the ocular surface [1]. In addition, all patients were experienced and successful contact lens wearers; the contact lenses were used to correct ametropia or for cosmetic purposes (e.g. tinted lenses).

We used a Humphrey 640 VFA computerized automated perimeter system (Humphrey, San Leandro, Calif.) with a customized program to study the differential light sensitivity (Fig. 1). This program allows determination of the luminous threshold (with a strategy of full threshold) at 50 points, besides foveal fixation, distributed within 60°. Regarding the distribution of the points as to eccentricity, 20 points are included within the central 30 deg (central area) and 30 points are between 30 deg and 60 deg (mid-periphery and periphery).

Regarding the topographic distribution of these points, each quadrant (superior temporal, inferior temporal, superior nasal, inferior nasal) incorporates 10 points, while another 10 points lie on the main meridians (six on the horizontal meridian, four on the vertical meridian). To analyze the results, we referred to the foveal threshold and the global sensitivity (GS) of the central and peripheral areas. The GS was obtained by calculating the arithmetic mean of threshold values. This was necessary because the customized program can disregard the standards on which the calculating mechanisms of the computer software are based, and it may be im-

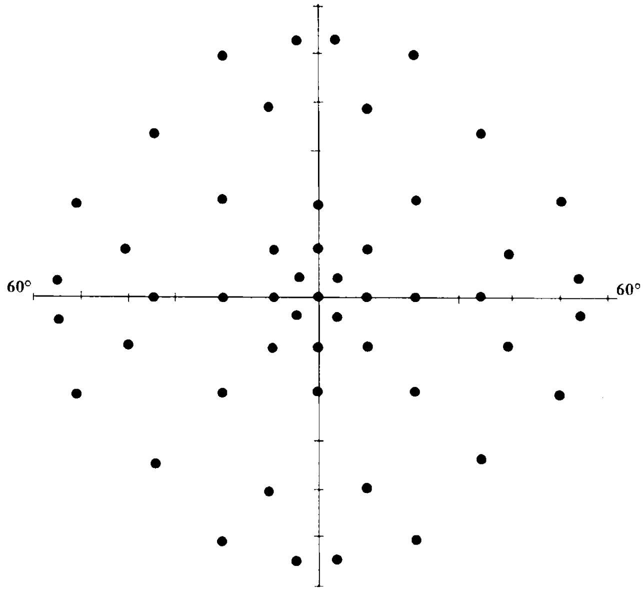

Fig. 1 Customized perimetry program that tests 50 points: foveal threshold, 20 points within the central area (central 30 deg), 30 points in the periphery (30–60 deg)

Table 1 Demographic and refractive data

Patient	Sex	Age (years)	Distance correction[a]	Usual correction
1	Female	51	+2.00	Two pair of glasses
2	Female	47	0.00	No correction for distance; glasses for near-vision
3	Female	49	0.00	No correction for distance; glasses for near-vision
4	Male	52	+1.75	Two pair of glasses
5	Female	47	+0.50	Glasses with multifocal lenses
6	Female	50	–2.50	Glasses for distance; no correction for near-vision
7	Female	51	+1.75	Glasses with multifocal lenses
8	Female	47	+0.75	Glasses with multifocal lenses
9	Male	55	+3.25	Glasses with multifocal lenses
10	Female	47	0.00	No correction for distance; glasses for near-vision
11	Male	51	+0.75	Glasses with multifocal lenses
12	Female	48	0.00	No correction for distance; glasses for near-vision
13	Male	45	+1.25	Glasses with multifocal lenses
14	Female	48	+1.25	Glasses with multifocal lenses
15	Female	52	+2.25	Glasses with multifocal lenses
16	Female	53	+4.00	Glasses with multifocal lenses
17	Female	55	+1.75	Glasses with multifocal lenses
18	Female	51	+2.50	Glasses with bifocal lenses
19	Female	54	+1.00	Glasses with multifocal lenses
20	Male	51	–2.25	Glasses for distance; no correction for near-vision
21	Female	50	–6.00	Contact lenses for distance; addiction with glasses for near-vision

[a] Distance correction of the randomly enrolled eye, expressed as spherical equivalent

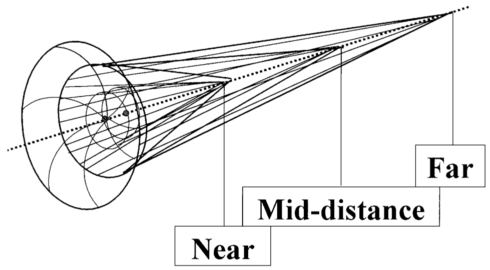

Fig. 2 Diagram of multifocal contact lenses. The lenses are spherical and doubled-curved, and the anterior surface consists of thousands of microcurves of about 10 µm each, which determine the possibilities for far, mean, and near vision

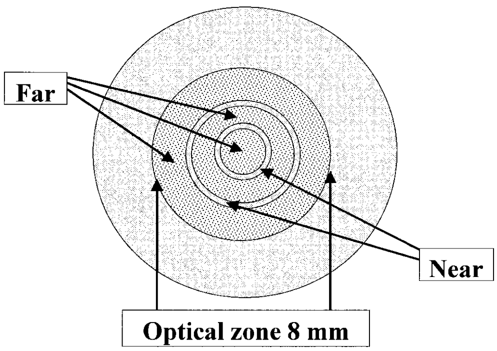

Fig. 3 Diagram of bifocal contact lenses. The lenses are spherical and composed of five concentric rings in the optical area (central 8 mm) in which the distance (three rings, including the central ring) and near (two rings) corrections are alternate

possible to calculate the perimetric indexes and elaborate the probability maps.

Both eyes of each patient were fitted with multifocal and bifocal contact lenses, with the goal of achieving the best-corrected ametropia and presbyopia. One randomly chosen eye of each patient was enrolled in the study of the visual field. At baseline, written, informed consent was obtained from each patient before their inclusion in the study.

The multifocal contact lenses (Continua, Ciba Vision, Duluth, Ga.) have the following characteristics: material, Hema Benz; 38% water; diameter, 14.00 mm; central thickness, 0.14 mm per –2.00 D; gas permeability (DK/T 64×10^{-9} [FATT system, 35°]). These lenses are spherical, double curved, and their anterior surface consists of thousands of microcurves of about 10 µm each, which determine different visual possibilities for far, mean, and near vision (Fig. 2). Each patient received two multifocal lenses that were to be worn daily for 6 months.

The bifocal contact lenses (Acuvue Bifocal, Vistakon, Johnson and Johnson) had the following characteristics: material, Etafilcon A; 58% water; diameter, 14.2 mm; central thickness, 0.075 mm per –3.00 D; gas permeability (DK/T, $27\pm2.00\times10^{-9}$ [FATT system, 35°]). These lenses are spherical and composed of five concentric rings in the optical area (central 8 mm), in which the distance (three rings, including the central ring) and near (two rings) corrections are alternate (Fig. 3). Each patient received 12 pairs of bifocal contact lenses that were to be worn daily for 15 days. All patients were required to use both types of lenses for a minimum of 6 h to a maximum of 10 h daily. A solution of hydrogen peroxide 3% was used to disinfect and preserve both types

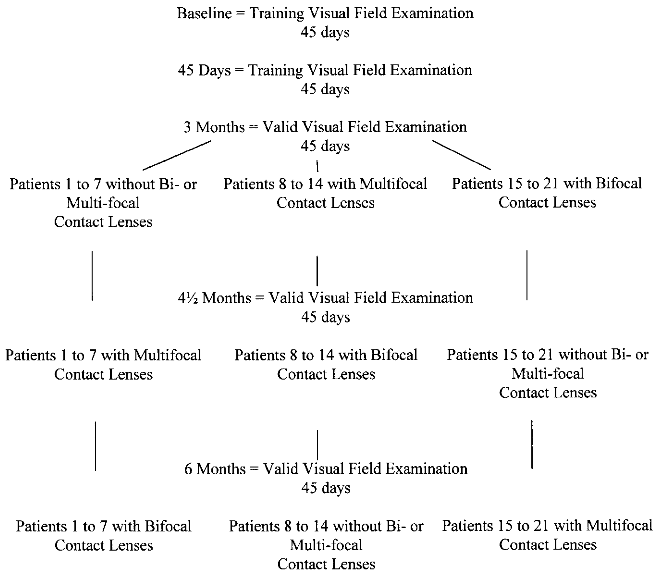

Fig. 4 Examination schedule

of lenses. A single-phase cleaning system was used, which included a solution of hydrogen peroxide 3% to disinfect the lenses and a special container with a platinum catalyst to neutralize the peroxide.

At baseline and after 45 days, each patient underwent visual field testing to be trained in the use of the perimeter and to minimize the learning effect associated with it [5].

After the examination at 45 days, seven randomly chosen patients received multifocal contact lenses (group 2) and seven randomly chosen patients received bifocal contact lenses (group 3); seven randomly chosen patients did not receive contact lenses (group 1). At 3 months, the first valid visual field examination was performed on the patients wearing the correction that has been used for the previous 45 days. Identical new fresh lenses were given to each patient 15 min before the examination to avoid influencing the examination results by the use of lenses of different ages. These lenses were used just for the visual field examination. Each patient was required to come to the examinations after wearing the lenses for 4–6 h.

Visual field testing in the eyes with contact lenses (groups 2 and 3) was performed without any other correction; visual field testing of the eyes without multifocal or bifocal contact lenses correction (group 1, controls) was performed with the near-vision correction using monofocal contact lens for testing the central 30 deg of vision; the corrective lens was removed for the periphery examination (30–60 deg). The monofocal contact lenses (1-Day Acuvue, Vistakon, Johnson and Johnson) had the following characteristics: material, Etafilcon A; 58% water; diameter, 14.2 mm; central thickness, 0.07–0.11 mm; gas permeability (DK/T, $27\pm2.00\times10^{-9}$ [FATT system, 35°]).

At the end of this examination, the first crossover was made to another type of correction for each patient studied.

At the examination performed at 4.5 months after the start of the study, visual field testing was performed in the same manner as at the 3-month examination; at the end of the examination the second change of correction was made. At the 6-month examination, visual field testing was done for the last time. Therefore, each eye was examined at 3, 4.5, and 6 months and each eye was examined without multifocal or bifocal contact lenses (control group), with multifocal contact lenses, and with bifocal contact lenses (Fig. 4).

Subjective rating

The opinions of the patients regarding the quality of their vision with each type of correction were elicited at the 3-, 4.5-, and 6-month examinations.

At 3 months, patients 1–7 expressed their opinions about their usual correction (control group) (Table 1), patients 8–14 about correction with multifocal contact lenses, and patients 15–21 about correction with bifocal contact lenses. At 4.5 months, patients 1–7 expressed their opinions about correction with multifocal contact lenses, patients 8–14 about correction with bifocal contact lenses, and patients 15–21 about their usual correction (control group) (Table 1). At 6 months, patients 1–7 expressed their opinions about correction with bifocal contact lenses, patients 8–14 about their usual correction (control group) (Table 1), and patients 15–21 about correction with multifocal contact lenses.

The subjective ratings provided a simple score of patient satisfaction with vision expressed on a scale of 1–4, with 1 indicating insufficient, 2 sufficient, 3 good, and 4 excellent. We intentionally avoided more specific questions that would have distinguished between far and near vision, wanting only to obtain the patients' ratings of their degree of satisfaction with their classical correction (control group), after using multifocal contact lenses, and after using bifocal contact lenses.

At 3, 4.5, and 6 months, each patient's best-corrected distance visual acuity in binocular vision was evaluated at 4 m by means of the Ferris Early Treatment Diabetic Retinopathy Study visual acuity chart [9, 10] and the near visual acuity in binocular vision was evaluated from 30 to 40 cm by type sizes [14]. At the same time points, we also evaluated each patient by slit-lamp examination to detect any alteration of the ocular surface or sign of ocular discomfort.

Statistical analysis

We used the non-parametric Wilcoxon signed rank test because of non-gaussian data distribution. We conducted a 2×2 comparison of the three groups of patients based on the results of the visual field: foveal threshold with monofocal contact lenses (group 1, control group) versus foveal threshold with multifocal contact lenses (group 2), foveal threshold monofocal contact lenses (group 1) versus foveal threshold with bifocal contact lenses (group 3), foveal threshold with multifocal contact lenses (group 2) versus foveal threshold with bifocal contact lenses (group 3). The same comparison was made between the GS of the central area (group 1 vs 2; 1 vs 3; 2 vs 3) and the GS of the periphery (group 1 vs 2; 1 vs 3; 2 vs 3).

We also conducted a 2×2 comparison of the three groups of patients based on their subjective ratings, using the Wilcoxon signed rank test: the degree of satisfaction with their classical correction (group 1, control group) versus that with multifocal contact lenses (group 2); the degree of satisfaction with their classical correction (group 1, control group) versus that with bifocal contact lenses (group 3); and the degree of satisfaction with multifocal contact lenses (group 2) versus that with bifocal contact lenses (group 3).

Finally, we evaluated the level of concordance (K of Cohen) between the objective data (global sensitivity obtained by visual field examination) and the subjective data (degree of satisfaction).

Results

The final sample consisted of 21 eyes of 21 patients. Nine patients were lost during follow-up; all left the study for personal reasons, such as insufficient time for examinations. Four patients left the study after the second training visual field examination (45 days), and five patients left after the examination at 3 months.

No significant difference in foveal threshold was found among the groups (Table 2).

A statistically significant difference was found both between the GS of the central area of the visual field in

Table 2 Foveal threshold values (dB) in the three groups

Eye	With monofocal contact lenses (control group/group 1)	With multifocal contact lenses (group 2)	With bifocal contact lenses (group 3)
1	35	34	35
2	36	35	35
3	37	37	36
4	36	37	37
5	35	34	35
6	34	33	34
7	32	32	32
8	32	31	33
9	29	30	30
10	32	31	31
11	29	30	29
12	35	34	35
13	33	33	34
14	34	33	34
15	32	32	33
16	33	33	34
17	33	31	32
18	32	32	33
19	35	36	35
20	32	32	32
21	34	33	33
Total	700	693	702
Mean (SD)	33.33 (2.11)	33.00 (2.02)	33.43 (1.96)
Median (MAD)	33.00 (1.00)	33.00 (1.00)	34.00 (1.00)

No statistically significant differences were found among the three groups (1 vs 2; 1 vs 3; 2 vs 3) (P>0.05)

Table 3 Sensitivity values (dB) of the central 30 deg of the visual fields in the three groups

Eye	With monofocal contact lenses (control group/group 1)	With multifocal contact lenses (group 2)	With bifocal contact lenses (group 3)
1	473	512	532
2	563	487	557
3	570	594	624
4	572	594	597
5	604	568	514
6	556	541	390
7	533	531	556
8	582	567	547
9	494	455	459
10	528	487	474
11	552	535	510
12	508	475	450
13	580	586	570
14	520	587	530
15	553	521	486
16	556	552	525
17	575	554	490
18	564	621	550
19	498	506	464
20	502	486	464
21	373	395	390
Total	11256	11154	10679
Mean (SD)	536.00 (50.75)	531.14 (54.93)	508.52 (60.84)
Median (MAD)	553.00 (25.00)	535.00 (48.00)	514.00 (42.00)

Statistically significant differences were found between patients with monofocal contact lenses and those with bifocal contact lenses (P=0.027) and between patients with multifocal contact lenses and those with bifocal contact lenses (P=0.026). No statistically significant difference was found between patients with monofocal contact lenses and those with multifocal contact lenses (P>0.05)

Table 4 Global sensitivity values (dB) of the visual field periphery (30–60 deg) in the three groups

Eye	Without contact lenses (control group/group 1)	With multifocal contact lenses (group 2)	With bifocal contact lenses (group 3)
1	359	337	276
2	411	395	361
3	548	484	496
4	598	463	518
5	597	549	488
6	511	544	453
7	426	447	419
8	633	437	423
9	389	356	348
10	386	373	339
11	406	379	382
12	269	267	250
13	464	533	480
14	562	540	490
15	403	369	422
16	440	417	368
17	201	527	525
18	485	420	420
19	308	449	380
20	277	279	372
21	480	495	465
Total	9153	9060	8675
Mean (SD)	435.86 (115.82)	431.43 (84.47)	413.10 (75.37)
Median (MAD)	426.00 (67.00)	437.00 (64.00)	420.00 (52.00)

No statistically significant differences were found among the groups (1 vs 2; 1 vs 3; 2 vs 3) (P>0.05)

the patients with monofocal contact lenses (group 1) and that of the patients with bifocal contact lenses (group 3) (P=0.027) and between the GS of the central area with multifocal contact lenses (group 2) and that with bifocal contact lenses (group 3) (P=0.026). In both cases, a significant reduction of the GS was observed when bifocal contact lenses were used.

No statistically significant differences in the GS of the central visual fields were seen between the patients with monofocal contact lenses (group 1) and the patients

Table 5 Degree of patient satisfaction (*1* insufficient, *2* sufficient, *3* good, *4* excellent)

Patient	Satisfaction with usual correction (control group/group 1)	Satisfaction with multifocal contact lenses (group 2)	Satisfaction with bifocal contact lenses (group 3)
1	3	3	3
2	4	3	3
3	4	4	4
4	4	3	3
5	4	3	2
6	3	3	2
7	3	3	3
8	3	3	2
9	2	2	2
10	3	2	2
11	4	3	2
12	3	3	2
13	4	4	3
14	3	3	2
15	3	2	2
16	2	2	2
17	3	3	2
18	3	3	2
19	3	3	2
20	3	2	2
21	2	2	2
Total	66	59	49
Mean (SD)	3.14 (0.65)	2.81 (0.60)	2.33 (0.58)
Median (MAD)	3.00 (0.00)	3.00 (0.00)	2.00 (0.00)

Statistically significant differences were found between patients with their usual correction and those with multifocal contact lenses (P=0.008), between patients with their usual correction and those with bifocal contact lenses (P<0.001), and between patients with multifocal contact lenses and those with bifocal contact lenses (P=0.002)

with multifocal contact lenses (group 2) (P>0.05) (Table 3). No significant difference among the three groups was found in the GS of the peripheral visual field (Table 4).

Considering myopic eyes (nos. 6, 20, 21; Table 1)as a separate group, the results show a trend toward a reduction in differential light sensitivity, especially concerning the central 30 deg (albeit not statistically significant).

No statistically significant correlation was present between age and differential light sensitivity.

Subjective rating

The patients' average degree of satisfaction was good with their usual correction (mean score 3.14), nearly good with multifocal contact lenses (mean score 2.81), and more than sufficient with bifocal contact lenses (mean score 2.33). The degree of satisfaction was statistically significant higher when using the usual correction (group 1) than with multifocal contact lenses (group 2; P=0.008) or with bifocal contact lenses (group 3; P<0.001), and higher with multifocal contact lenses (group 2) than with bifocal contact lenses (group 3; P=0.002) (Table 5).

Level of concordance (K of Cohen)

A good level of concordance between the objective data (global sensitivity of central area of visual field) and the subjective data (degree of satisfaction) was found (K of Cohen = 0.231) [7].

Visual acuity and ocular surface

At every time point for each patient, the best-corrected distance visual acuity evaluated in binocular vision was 20/20 (from 4 m) using the Ferris Early Treatment Diabetic Retinopathy Study visual acuity chart [9, 10] and type size 6 at near (from 30 to 40 cm) [14].

All subjects wore the lenses without objective signs of discomfort throughout the study. No alterations of the ocular surface were observed.

Discussion

Differential light sensitivity may be an important parameter of the visual performance of a contact lens-wearing eye.

In the past other authors have dealt with the impact of contact lens wearing on perimetry [3, 16], but none of the studies has ever confronted the problem of the relation with the quality of vision obtained by contact lenses or evaluated the performance of multifocal and bifocal contact lenses.

Our study aimed to compare the subjective evaluation of the quality of vision obtained with different corrective methods and the quantitative differential light sensitivity findings with the same corrective system in the same patients.

Our results showed that even if the best-corrected distance visual acuity was 20/20 (from 4 m) and type size 6 at near (30–40 cm) with both bifocal and multifocal contact lenses, when the patients were asked to express their opinions about their vision, their satisfaction with bifocal contact lenses was lower than that with multifocal contact lenses or with their usual correction (control group) (Table 5).

The perimetric study showed no statistically significant changes in foveal threshold among the different groups (different kinds of contact lens worn), while significant changes occurred in global sensitivity of the central 30 deg. In fact, the results of the perimetric evaluation show a worsening of differential light sensitivity with bifocal contact lenses compared with multifocal contact lenses and monofocal contact lenses (control group). Conversely, no significant differences in differential light sensitivity emerged between multifocal contact lenses and monofocal contact lenses (control group).

Interpretation of these results is difficult. One possible reason for the patients' dissatisfaction is that the diffraction resulting from the passage of light among the concentric rings in the central 8 mm of the bifocal contact lenses (Fig. 3) [6, 21] may have caused reduced illumination of the central retina (Table 3), with a consequent significant reduction in the quality of vision in the corresponding area of the visual field.

With multifocal contact lenses, this diffractive phenomenon may not occur, or may occur to a smaller extent, because of the continuous microcurves on the outer lens surface (Fig. 2), and may guarantee a visual quality similar to the ideal visual conditions that result from the spherical surface of monofocal contact lenses and the spherical or cylindrical–spherical (cylinder 1.00 D) corneal surface.

It is important to underline that the central thickness and the materials of the studied contact lenses are different. This might in some manner influence the results of the visual field examination. However, it is notable that the relative thickness of bifocal contact lenses was lower than the one of multifocal lenses.

In conclusion, considering the degree of satisfaction expressed by patients and the good level of concordance between the degree of satisfaction and the GS of the central area of the visual field, our study shows that assessment of the differential light sensitivity by computerized automated perimetry is a better indicator than central visual acuity of the quality of vision achieved by contact lens wearers, reflecting more accurately the visual performance of these patients, and should be used to evaluate the global visual characteristics resulting from contact lens wearing.

Further studies on customized perimetric strategies (e.g. using Goldmann I targets to increase the sensitivity of the test [3]) or the use of other psychophysical techniques, such as movement or ring perimetry or electrophysiological tests [18], will probably further elucidate the complex mechanisms involved in the visual function of bifocal and multifocal contact lens wearers.

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