Effects of multifocal soft contact lenses used to slow myopia progression on quality of vision in young adults

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ABSTRACT.

Purpose: To assess the effects of multifocal soft contact lenses (MF SCLs) used for myopia control on visual acuity (VA) and subjective quality of vision.

Methods: Twenty-four young adult myopes had baseline high and low-contrast VAs and refractions measured and quality of vision assessed by the Quality of Vision (QoV) questionnaire with single vision SCLs. Additional VA and QoV questionnaire data were collected immediately after subjects were fitted with Proclear MF SCLs and again after a 2-week adaptation period of daily lens wear. Data were collected for two MF SCL designs, incorporating +1.50 and +3.00 D peripheral near additions, with a week washout period allowed between the two lens trials.

Results: High- and low-contrast VAs were initially reduced with both MF SCL designs, but subsequently improved to be not significantly reduced in the case of high-contrast VA by the end of the 2-week adaptation period. The quality of vision was also reduced, more so with the +3.00 D MF SCL. Quality of Vision (QoV) scores describing frequency, severity and bothersome nature of visual symptoms indicated symptoms worsening rather than resolving over the 2-week period, particularly so with the +3.00 D MF SCL.

Conclusion: Low and high add MF SCLs adversely affected vision on initial insertion, with sustained effects on low-contrast VA and QoV scores but not high-contrast VA. Thus, high-contrast VA is not a suitable surrogate for quality of vision. In prescribing MF SCLs for myopia control, clinicians should educate patients about these effects on vision.

Key words: multifocal soft contact lenses – myopia – quality of vision – visual acuity

Introduction

Myopia has traditionally been considered a 'mere refractive error', but recent steep increases in its prevalence around the world, particularly in South-East Asia, has forced a change in viewpoint (Jung et al. 2012; Sun et al. 2012; Holden et al. 2014, 2016; Williams et al. 2015). For example, myopia prevalence rates of around 95% appear in recent reports from China and Korea for young adult populations (Jung et al. 2012; Sun et al. 2012). It now represents one of the leading causes of preventable blindness, reflecting these high prevalence statistics and the adverse ocular health implications associated with myopia (Saw et al. 2005), even in low degrees (Flitcroft 2012).

The possibility that eye growth and thus myopia progression might be controlled optically is supported by studies involving a variety of animal models. Landmark studies have provided proof of principle that multifocal lenses can be used to slow experimentally induced myopia progression, also highlighting the important role of the peripheral retina in eye growth regulation (Smith et al. 2009; Liu & Wildsoet 2011, 2012; Benavente-Perez et al. 2012, 2014). This has also been found to occur in human trials as recently reported in a network meta-analysis on the subject (Huang et al. 2016). Specifically, lenses designed to impose myopic defocus on the peripheral retina slow axial length elongation (Liu & Wildsoet 2011), while the opposite effect is true for lenses imposing peripheral hyperopic defocus, that is the rate of elongation is increased (Smith et al. 2009; Liu & Wildsoet 2011; Benavente-Perez et al. 2014).

The above findings give credibility to the increasing use of myopia control optical devices, including concentric multifocal soft contact lenses (MF

SCLs), originally intended for presbyopia correction (Aller & Wildsoet 2008; Walline et al. 2013; Aller et al. 2016), and novel MF SCL designs intended for this purpose. Both progressive designs (Sankaridurg et al. 2011), in which the add increases from the edge of a defined central zone incorporating the distance correction, towards the periphery, and alternating designs (Anstice & Phillips 2011; Lam et al. 2014) are encountered. In their traditional application as presbyopic corrections and despite improvements in design and increases in the variety of MF SCL designs available, MF SCLs are generally under-prescribed (Morgan et al. 2011), at least in part reflecting low acceptance of the quality of vision provided (Plakitsi & Charman 1995; Bennett 2008; Gifford et al. 2013; Kollbaum et al. 2013; Mosquera & Alio 2014). As MF SCLs are designed to project multiple powers within the pupil, reductions in visual performance are not surprising. Nonetheless, for presbyopes who require both distance and near targets to be imaged on the retina, the benefits of simultaneous distance and near correction are obvious and may outweigh negatives such as reduced quality of vision. Motivation may not be as strong for children to wear MF SCLs for the purposes of myopia control, if visual function is adversely affected, given that the benefits of wearing such lenses are not immediately apparent to the wearer.

The study reported here aimed to investigate the effects on the visual performance of young adults of commercially available MF SCLs currently used for myopia control therapy, as measured by both high- and low-contrast VA, and the Quality of Vision (QoV) questionnaire. When high-contrast visual acuity (VA) is used as an index of the visual degradation caused by MF SCLs, negative results are frequently reported, leading to claims that the lenses do not significantly impair vision (Walline et al. 2013). However, high-contrast VA has proven to be a poor index of the quality of vision experienced by individuals in their everyday life (Papas et al. 2009; McAlinden et al. 2010). To make up for this deficiency, both low-contrast VA and the validated QoV questionnaire (McAlinden et al. 2010) were included in our study.

Subjects and Methods

Design

This study described here was embedded in a larger study of the effects on visual function of two MF SCL designs, details of which have been described previously (Kang & Wildsoet 2016). In brief, subjects were first fitted with single vision (SV) SCLs to determine their refractive error correction during an initial baseline (BL) testing session. For each of the two MF SCLs, subjects underwent two sets of measurements, the first set during an initial fitting session, approximately 5 min following lens settling (Study visit 1 or SV1), and the second set after 2 weeks of daily wear of the MF SCL (Study visit 2 or SV2). Subjects were asked to wear lenses for a minimum of 8 hr and a maximum of 14 hr each day. A week-long washout period was allowed between the completion of testing with the first of the two MF SCL and fitting of the second of the MF SCL. The order of testing of the two MF SCL designs was randomized across subjects.

This study followed the tenets of the Declaration of Helsinki, and approval was obtained from the Committee for Protection of Human Subjects (CPHS) of UC Berkeley before commencement of the study. All subjects gave their informed written consent prior to participation in the study after being informed about the nature of the study and possible adverse effects.

Subjects

Twenty-four young adult subjects were enrolled (age range 18–28 years; 20 females, four males). All subjects were screened before enrolment. Required inclusion criteria included spherical equivalent central (on-axis) refractive errors (M) between −1.00 and −6.50 D, with astigmatism ≤−0.75 D. The

refractive error profiles, described in power vectors (Thibos et al. 1997), and near phorias of the subjects, measured at 40 cm using the prism dissociation method, are summarized in Table 1 (Kang & Wildsoet 2016).

Lenses

The lenses used in this study included Proclear® spherical (SV) lenses, which were used to obtain baseline (BL) data, and two distance centre design Proclear® multifocal (MF) SCLs (omafilcon A, 62% water content; CooperVision, Victor, NY, USA), differing only in near addition power [+1.50 (MF1.5) or +3.00 D (MF3)]. The base curve and lens diameters for these SV and MF lenses are 8.6, 14.2, 8.7 and 14.4 mm, respectively. The MF SCLs have a progressive power lens design, with a central 2.3 mm distance correction zone, surrounded by an annular treatment zone in which the near addition correction is progressively introduced from the edge of the central distance correction zone and extending out to 8.5 mm. In all cases, lens centration, coverage and movement were assessed to confirm clinically acceptable fits before measurements were taken. Subjects wore each of the two MF lenses for 2 weeks on a daily basis and were provided with Alcon Optifree Puremoist multipurpose solution to clean and maintain contact lenses.

Measurements

As noted above, for the SV lenses, there was just one measurement session at the beginning of the study (BL), and for each of the two MF SCLs, there were two sets of measurements corresponding to the beginning and end of a 2-week period of daily lens wear. The same set of measurements was used in all sessions, undertaken under the same testing conditions. The illuminance

Table 1. Baseline objective refraction components M, J_{180} and J_{45}, for right and left eyes (D; mean ± SD) and near phorias (PD; mean ± SD).

Ocular parameter	Right eye	Left eye
M	−3.64 ± 1.51	−3.72 ± 1.87
J_{180}	0.06 ± 0.19	0.13 ± 0.20
J_{45}	0.05 ± 0.16	0.00 ± 0.13
Near Phorias*	−2.23 ± 3.05	

* Measured through single vision (SV) soft contact lenses. Negative values represent exophorias.

level measured at the examination chair in which subjects were seated was 148.5 lux.

Visual acuity

Monocular high- and low (50%)-contrast distance VAs were measured with a computerized VA chart (M&S Technologies Dallas, TX, USA) presented at 6 m and recorded in logMAR units.

QoV questionnaire

The QoV questionnaire (McAlinden et al. 2010) has been specifically designed to measure subjective quality of vision, including that afforded by contact lens wearers. It was administered at every study visit to explore the effects of the MFSCLs and changes over time. The QoV questionnaire addresses 10 specific visual symptoms: glare, halos, starbursts, hazy vision, blurred vision, distortion, double or multiple images, fluctuation in vision, focusing difficulties and difficulty in depth perception. Each symptom is scored on three scales – frequency, severity and bothersome, with the first seven symptoms, as listed above, having associated images to help standardize the scoring of visual symptoms (McAlinden et al. 2013). Rasch analysis is the gold standard in questionnaire development and validation (Gothwal et al. 2011; Khadka et al. 2011, 2012b, 2013; McAlinden et al. 2011a, 2012c) and underpins this QoV questionnaire. Specifically, Rasch scaling is used with logits converted to a 0- to 100-unit linear scale, with higher scores indicating poorer quality of vision (McAlinden et al. 2011b, 2012a,b; Khadka et al. 2012a,b; Skiadaresi et al. 2012).

Data analysis

Depending on the normality or otherwise of the data, either a repeated measures ANOVA or the Friedman test was used to assess contact lens-related and time-dependent changes in VAs and near phorias, with paired *t*-tests or Wilcoxon signed-rank test with Bonferroni correction applied *post hoc* to identify the origin of statistically significant outcomes. Differences in VAs recorded with single vision SCLs in place (BL) compared to VAs recorded with the two different MF SCLs at their fittings, as well as differences at the beginning and end of the wearing period for the MF SCLs, were analysed.

For Rasch-scaled QoV questionnaire data, a Friedman test was used to assess overall differences, with the Wilcoxon signed-rank test combined with Bonferroni correction applied *post hoc* in the case of significant results. A critical p value of 0.05 was used to denote statistical significance.

Results

Overall, MF SCLs tended to reduce high- and low-contrast distance VAs relative to performance measured through SV SCLs. The negative impact on vision of the MF SCLs was further highlighted by increase in frequency, severity and bothersome subscale scores with MF SCL compared to SV SCLs. For the MF SCLs, individual visual symptoms were either the same or more severe at the end compared to the beginning of the 2-week lens-wearing period and as expected, the high add (MF3) lens design impaired the quality of vision more than the low add (MF1.5) lens design. These effects of the MF SCLs are described in more detail below.

Visual acuity

The visual acuities (VAs) for right and left eyes through the SV SCLs were -0.05 ± 0.04 and -0.04 ± 0.04, respectively. Both the MF1.5 and MF3 SCLs reduced high- and low-contrast distance VA (Fig. 1A,B, respectively), although the effect of the MF1.5 SCLs failed to reach statistical significance, even at the initial fitting session. For the higher add lens design MF3, there was a significant reduction in distance high- and low-contrast VAs measured immediately after insertion (SV1: p = 0.006 and 0.021, respectively), and this reduction did not significantly change over the two-week lens-wearing period (SV1 compared to SV2; all p > 0.05). These contrasting trends for the three contact lenses are well illustrated in Fig. 1.

QoV

With the MF SCLs, there were significant increases in the scores with the QoV questionnaire for all three subscales (frequency, severity and bothersome), relative to scores recorded for the SV SCLs, implying that the quality of vision was reduced with the MF SCLs in place. Note that for the lower add MF1.5 lens (SV1), subjects did not report any initial decrease in the quality of their vision, as reflected in differences in scores in QoV questionnaires completed after the initial insertion of the MF1.5 lenses compared to scores recorded with SV lenses in place (SV1-BL), while returning subjects reported significant increases in symptoms. With the higher add MF3 lenses, scores from QoV questionnaires indicate that the quality of vision at the initial fitting was reduced (SV1-BL) and that further deterioration occurred over the 2-week lens-wearing period (SV2-SV1). Thus, with both MF SCLs, there was no evidence of adaptation over the 2 weeks of lens wear in terms of visual symptoms.
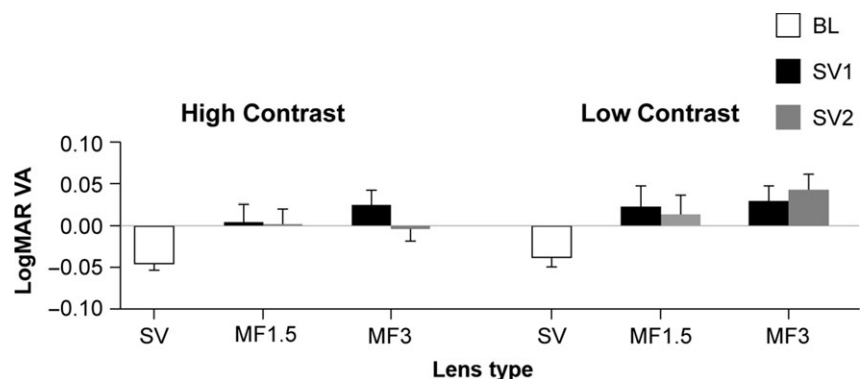
Fig. 1. High- (left) and low (right)-contrast distance VAs for right eyes measured with single vision (SV) soft contact lenses (SCLs), and two multifocal (MF) SCLs, MF1.5 and MF3, at the beginning and end (SV1 and SV2) of a 2-week period of daily wear in the latter cases. Error bars represent standard errors of the mean.

Table 2. Rasch-scaled scores on frequency, severity and bothersome scores of overall Quality of Vision (QoV) symptoms with single-vision (SV) lenses at BL measurement session, as well as MF1.5 and MF3 lenses at SV1 and SV2 measurement sessions. The scale extends from 0 to 100, with higher scores indicating worse quality of vision.

Lens design Study visits	Single vision BL	MF1.5		MF3	
		SV1	SV2	SV1	SV2
Frequency	20.50 ± 18.13	23.63 ± 18.05	38.46 ± 20.36	48.00 ± 11.68	61.58 ± 12.97
Severity	15.54 ± 15.64	18.29 ± 15.83	29.46 ± 16.89	38.04 ± 8.45	47.71 ± 12.24
Bothersome	12.38 ± 15.25	15.38 ± 15.24	28.00 ± 20.05	38.17 ± 12.69	51.79 ± 16.06
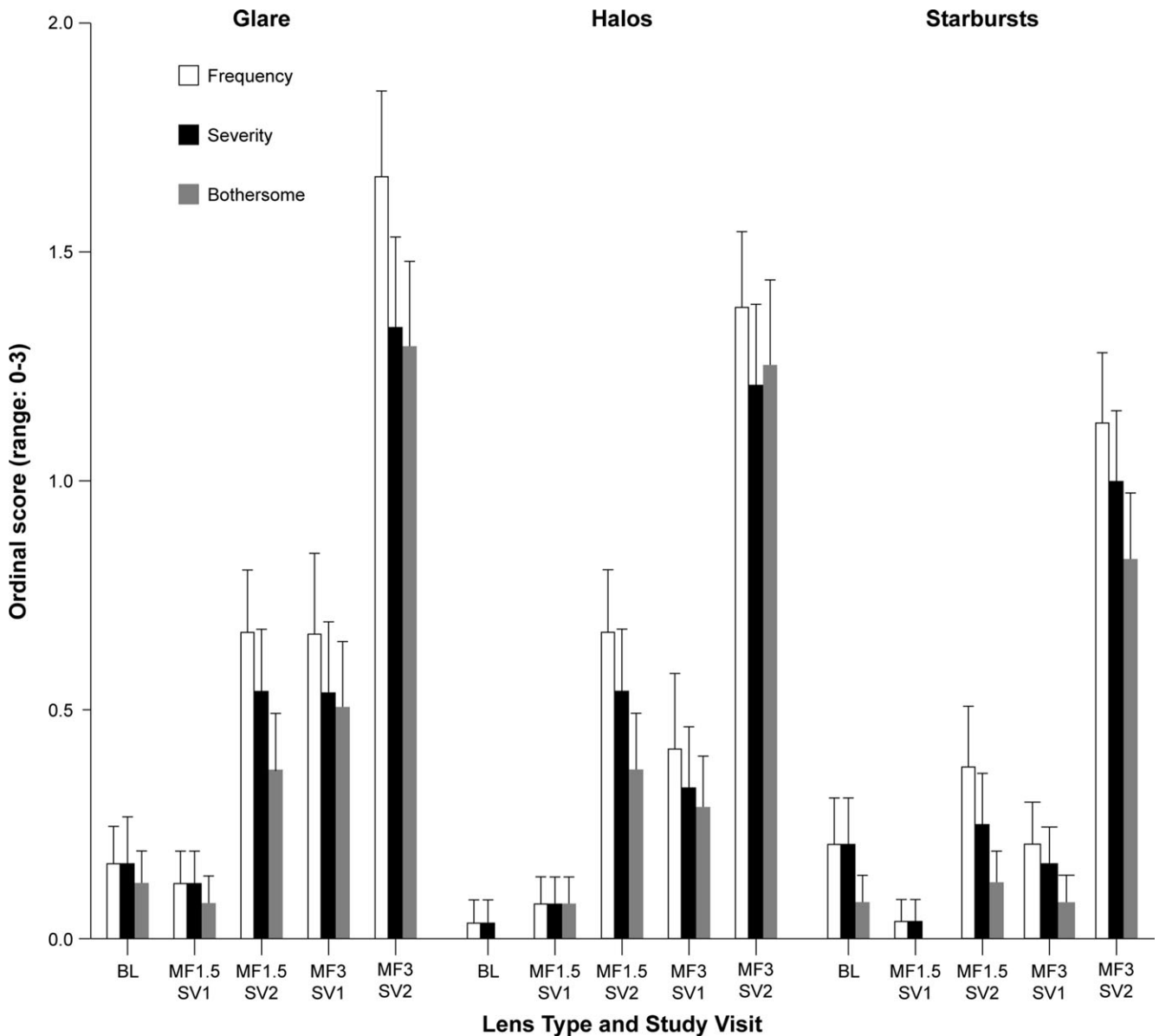
Fig. 2. Frequency, severity and bothersome scores of glare (left), halo (middle) and starburst (right) symptoms with SV SCLs at BL, and with the lower add MF1.5 and higher add MF3 SCLs, at SV1 and SV2. Error bars represent standard errors of the mean.

Overall, for frequency, severity and bothersome, total scores derived from the QoV questionnaires were not significantly affected by the MF1.5 SCLs initially, that is at SV1, compared to SV SCLs (at BL) (p = 0.364, 0.355 and 0.350, respectively). However, compared to the initial scores recorded with the MF1.5 lenses, all three scores were significantly increased after 2 weeks of daily lens wear (SV2 versus SV1: frequency, p = 0.001; severity, p = 0.002; bothersome, p = 0.002). With the higher add MF3 SCLs, scores recorded at the initial lens fitting were significantly higher than those recorded with the SV SCLs (SV1 versus BL; all

p < 0.001), and there was a further significant increase in scores after the 2 weeks of daily lens wear (SV2 versus SV1, all p < 0.05). These data are summarized in Table 2.

To understand the nature of the decrease in quality of vision with the MF SCLs and differences in performance between the lens designs, the scores for individual visual symptoms have been plotted for the SV SCLs at BL, and for the MF1.5 and MF3 SCLs, at the beginning (SV1) and end (SV2) of the 2-week daily lens-wearing period (Figs 2–6). Here also, individual visual symptoms were generally greater with

the higher add MF3 compared to the lower add MF1.5 lens design. Furthermore, symptoms were generally more severe at the end compared to the beginning of the 2-week period of daily lens wear (SV2 versus SV1). With both lens designs and all study visits, the frequency of symptoms tended to be greater than the level of severity, followed by bothersome. The trends for individual visual symptoms with MF1.5 and MF3 lenses across the lens-wearing period are described in more detail below, and results of statistical comparisons across visits are shown in Table 3.

Glare, halos and starbursts
Compared to SV SCLs at BL, an increase in the frequency of glare and halo symptoms and an increase in the severity and bothersome nature of halo symptoms were noticed after 2 weeks of MF1.5 lens wear. Both glare and halo symptoms significantly increased over the 2-week lens-wearing period. There was no significant difference in starburst symptoms with MF1.5 lenses compared to SV SCLs. On the other hand, insertion of MF3 SCLs resulted in a significant increase in glare and halo symptoms compared to scores for the SV SCLs (BL), and
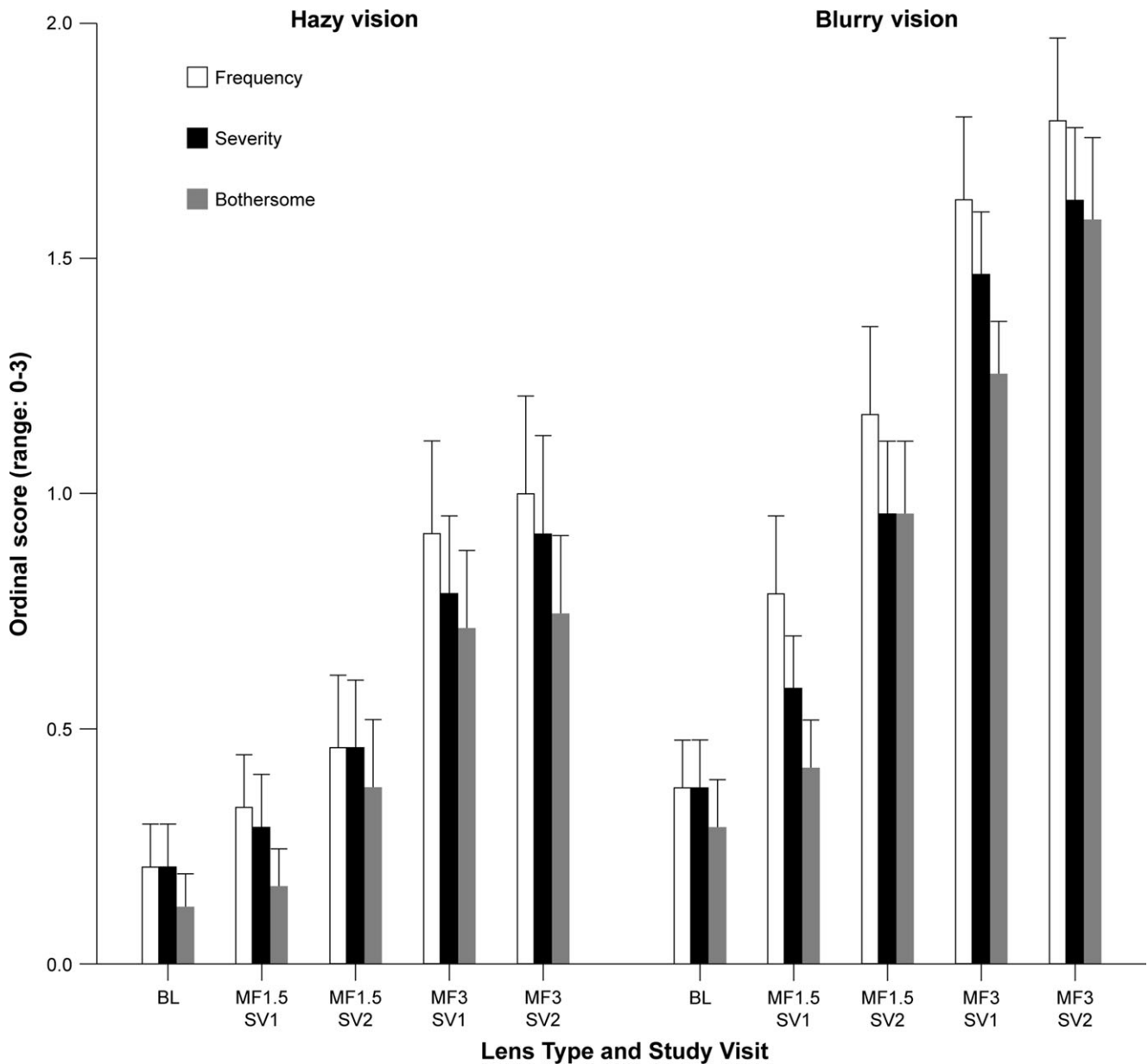

Fig. 3. Frequency, severity and bothersome scores of hazy (left) and blurred (right) vision experienced with SV SCLs at BL, and with the lower add MF1.5 and higher add MF3 SCLs, at SV1 and SV2. Error bars represent standard errors of the mean.

all symptoms increased significantly in terms of frequency, severity and bothersome scores, over the 2-week lens-wearing period.

Hazy and blurred vision

There was no difference in hazy vision symptoms experienced with MF1.5 SCLs compared with SV SCLs. However, compared to SV SCLs at BL, there was a significant increase in blurred vision symptoms with MF1.5 SCLs, which increased to become statistically significant after 2 weeks of lens wear. In contrast, the higher add MF3 SCLs resulted in significant hazy and blurred vision symptoms on initial lens insertion (SV1 versus BL) and these symptoms remained unchanged over the 2-week lens-wearing period.

Distortion and double vision

Neither distortion nor double vision was characteristic of the visual symptoms associated with MF SCL wear. There was no difference in the scores recorded with the MF1.5 compared to SV SCLs at BL, and in the case of the MF3 SCLs, only one symptom and one rating, the severity of distortion, showed a statistically significant increase over the wearing period.

Fluctuation in vision and focusing difficulties

Compared to SV SCLs at BL, there was an increase in the frequency, severity and bothersome nature of fluctuations in vision with the MF1.5 SCLs, which increased to become statistically significant after 2 weeks of lens wear. In comparison, the MF1.5 SCLs had minimal effect on focusing ability, as quantified by symptoms of focusing difficulties. With MF3 lenses, there was an increase in fluctuations in vision and focusing difficulties on initial lens insertion compared to SV SCLs (SV1-BL) and these symptoms persisted unchanged over the 2-week lens-wearing period.

Depth perception

Neither of the MF SCLs affected depth perception, relevant scores being similar for all three SCLs and unchanged across the wearing period for the MF1.5 and M3 SCLs (Fig. 6).

Discussion

This study investigated in young myopic adults the effects on the quality of vision of commercially available low and high add MF SCLs, as prescribed for myopia control. The reference was SV SCLs. Although high-contrast VA has been used in some past studies to evaluate the effects on vision of MF SCLs (Walline et al. 2013), its sensitivity as a quality of vision metric has also been challenged in some studies (Papas et al. 2009; McAlinden et al. 2010). Thus, to address the above question in the current study, both low-contrast VA and a QoV questionnaire were also included. Overall, compared to SV SCLs, both the MF1.5 and MF3 SCLs reduced low-contrast VA and the quality of vision for wearers, and not surprisingly symptoms were worse with the high add MF3 compared to low add MF1.5 SCLs. Interestingly, many symptoms increased over the 2-week lens-wearing period, particularly for the high add (MF3) lens, and symptoms rarely decreased over the same period, even for the low add (MF1.5) lens. Increases in the frequency of visual symptoms were the most obvious change with the MF SCLs, followed by increases in the severity then the bothersome nature of symptoms.

When the patterns of change in high- and low-contrast VAs are compared to changes in QoV with MF1.5 lenses, some similarities are in evidence. High- and low-contrast VAs tended to be reduced and most symptoms included in the QoV questionnaire increased after insertion of the MF1.5 SCL
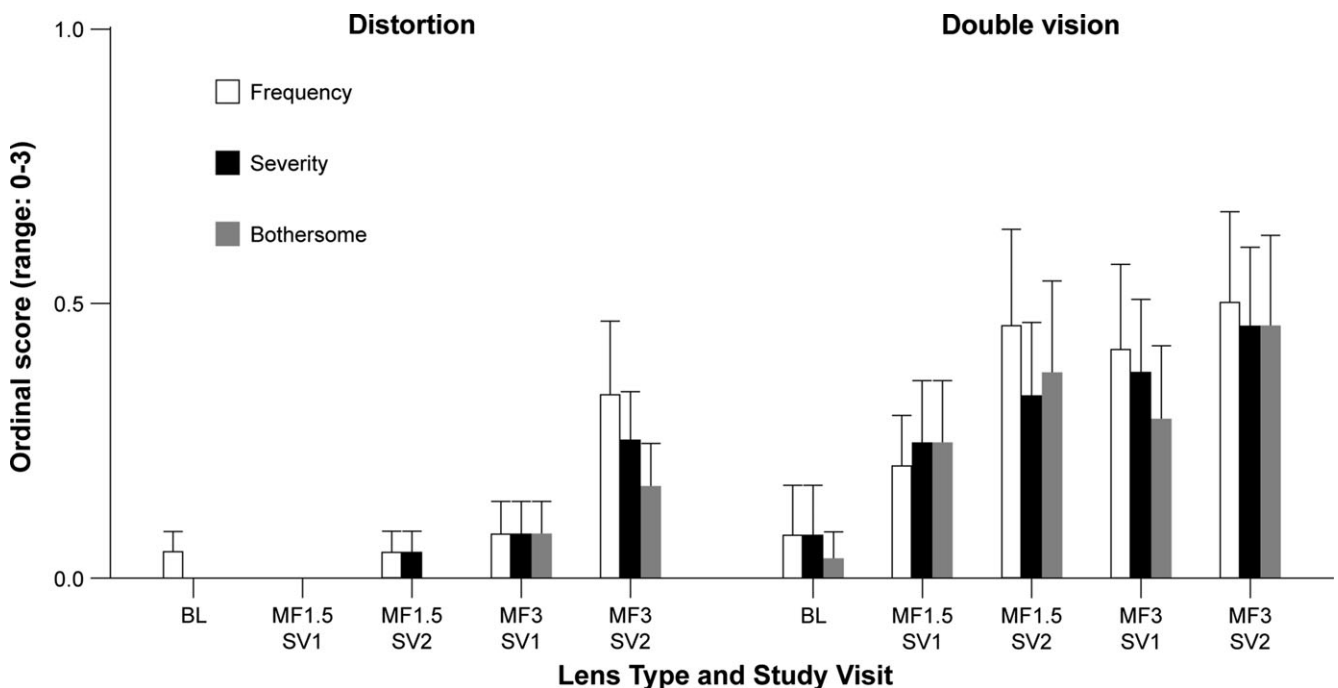

Fig. 4. Frequency, severity and bothersome scores of distortion (left) and double (right) vision noticed with SV SCLs at BL, and with the lower add MF1.5 and higher add MF3 SCLs, at SV1 and SV2. Error bars represent standard errors of the mean.
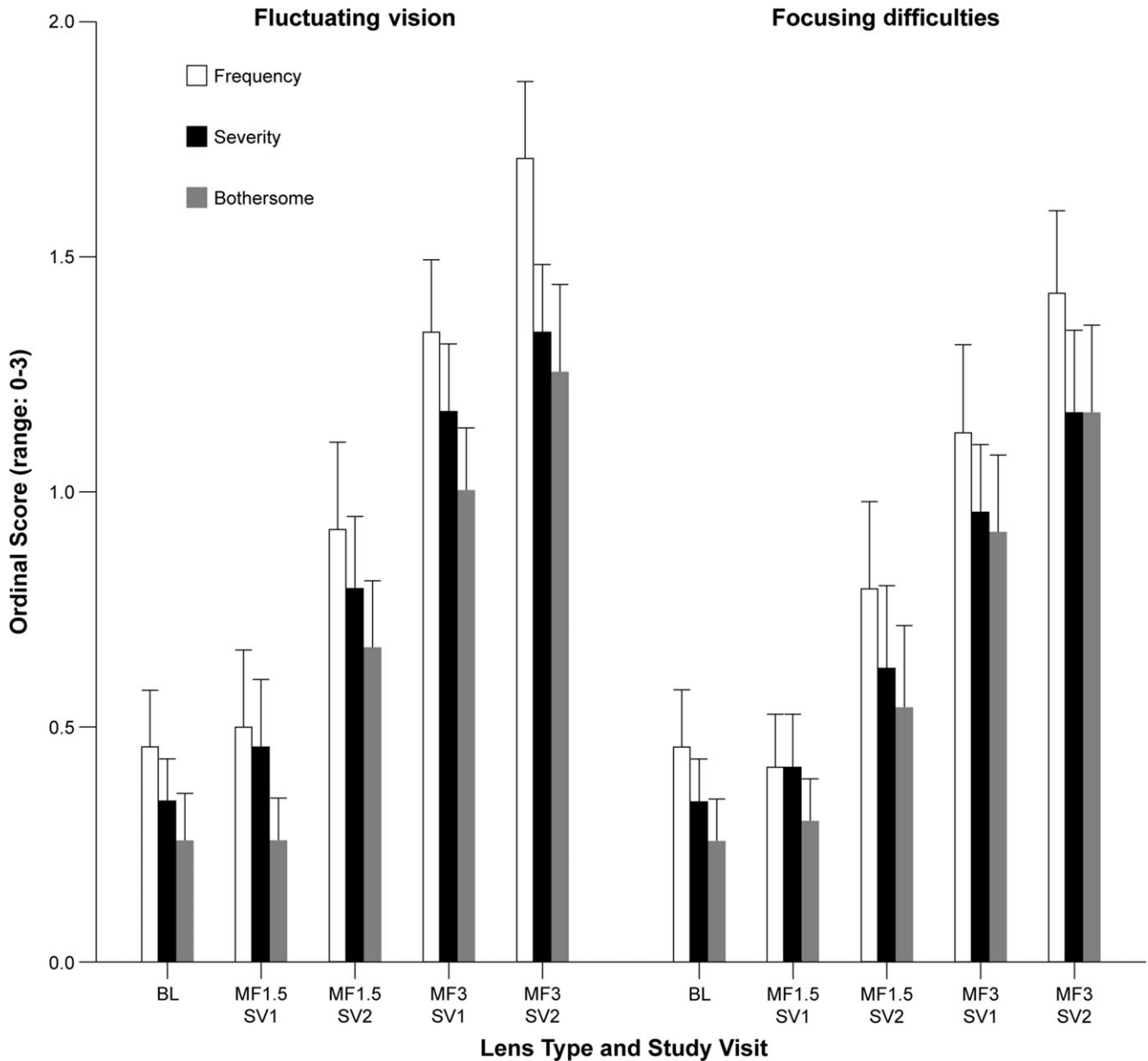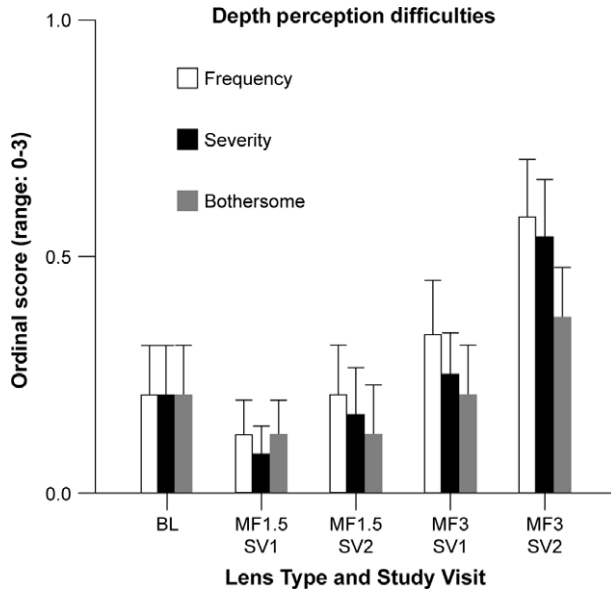
Fig. 5. Frequency, severity and bothersome scores of fluctuating vision (left) and focusing difficulties (right), recorded with SV SCLs at BL, and with the lower add MF1.5 and higher add MF3 SCLs, at SV1 and SV2. Error bars represent standard errors of the mean.

(SV1) compared to SV SCL at BL, with the exception of glare and starburst symptoms, and depth perception difficulties, which were not affected. Nonetheless, both high- and low-contrast VAs appeared less-sensitive measures of effects on the quality of vision, at least for the MF 1.5 SCL, whose effects were also more subtle than those of the MF3 SCL. Thus, although there were obvious increases in the frequency, severity and bothersome scores for most visual symptoms with MF1.5 SCL over the 2 week lens-wearing period, no change in either high- or low-contrast VAs was documented

over the same period. Noteworthy is the finding that the MF1.5 SCLs did not increase distortion symptoms or depth perception difficulties as compared against SV SCLs.

The disparity between VA and quality of vision data is more apparent with the high add (MF3) SCL. High-contrast VA improved after 2 weeks of lens wear, presumably reflecting adaptation, as has been reported after prolonged exposure to defocus in other studies, specifically improvements in detection and letter recognition (Mon-Williams et al. 1998; George & Rosenfield 2004; Rosenfield et al. 2004;

McAlinden & Moore 2011; Poulere et al. 2013). However, the opposite trend was observed with low-contrast VA in the current study; low-contrast VA was reduced on insertion of the MF 3 SCL and deteriorated further over the 2-week lens-wearing period. This pattern of change for low-contrast VA is similar to the trends in QoV scores; specifically, there were increases in visual symptoms with insertion of the MF3 SCL and further increases over the 2-week lens-wearing period, with no evidence of adaptation. The gradients of change in the frequency, severity and bothersome nature of

Fig. 6. Frequency, severity and bothersome scores of depth perception difficulties experienced with SV SCLs at BL, and with the lower add MF1.5 and higher add MF3 SCLs, at SV1 and SV2. Error bars represent standard errors of the mean.

three symptoms – distortion, double vision and depth perception difficulties, experienced with MF3 lenses over the 2-week lens-wearing period, were considerably flatter than for other symptoms included in the questionnaire. While the results for the first three symptoms may reflect, at least in part the optical design of the MF lenses, it must also be acknowledged that the weighting given to various visual symptoms and their functional significance will likely be different for children and adolescents compared to adults. For example, symptoms of glare, halos and starbursts will be functionally relevant to adults needing to drive at night. On the other hand, symptoms such as hazy or blurred vision, fluctuating vision and focusing difficulties may be more apparent and relevant to children and adolescents, at least during the school year. As our subjects were college-age students, night-time activities would perhaps have been biased towards near work, as opposed to night driving.

The results of the current study suggest that low-contrast VA may be a sufficiently sensitive indicator of overall quality of vision experienced by individuals wearing MF SCLs. In a previous study (Kollbaum et al. 2013) exploring differences in visual performance between contact lenses with either a progressive power profile (distance centre Proclear multifocal) or a concentric, dual-focus design (MiSight;

CooperVision, New Territories, Hong Kong), compared to best-spectacle distance corrections, no differences were found in high-contrast VA, irrespective of the types of letters used. However, similar to results of the current study, reductions in low-contrast VA were recorded with both multifocal lens designs compared to best-spectacle distance correction, at both far and intermediate distances (Kollbaum et al. 2013). Together, our data argue for the use of low-contrast but not high-contrast VAs where a simple, screening test of the quality of vision experienced by individuals is required (Papas et al. 2009; McAlinden et al. 2010).

Changes in near phorias with the low and high add MF SCLs were reported in our earlier paper (Kang & Wildsoet 2016). With both lens designs, changes in the exo-direction were observed, slightly greater with the high add design (-3.69 ± 0.62 PD for MF1.5 SCL; -4.94 ± 0.62 PD with MF3 SCL at SV1). It is plausible that such changes in phorias may underlie some of the changes in visual symptoms described here, should fusional vergence reserves not be adequate to compensate for the imposed mismatch between accommodation and convergence demands. Blurred vision, fluctuating vision and focussing difficulties are all possible expressions of related binocular vision problems, although such symptoms may also occurs as

products of the multifocal optics of the lenses. Note that because our subjects were college students, with significant near work demands associated with their studies, they may also have been aware of and less tolerant of any degradation in the quality of their near vision than nonstudents.

The current study only followed subjects over a short, 2-weeks lens-wearing period. Thus, the results need not reflect the longer-term visual effects of the MF SCLs. For example, in a study involving laser refractive surgery [laser-assisted subepithelial keratectomy (LASEK)], the QoV was found to be initially reduced, at both 5 days and 2 weeks after the surgery, but it returned to pre-LASEK levels by 1 month after the surgery and showed an absolute improvement at 3 months postsurgery (McAlinden et al. 2011c). It is possible that the visual symptoms captured by the QoV questionnaire in the current study would similarly ameliorate with longer-term wear of the MF SCLs for myopia control, given that changes in the optical aberrations of the eye are the likely origin of at least some visual symptoms for both the above refractive surgery and the MF SCLs tested here. Curiously, our subjects recorded deteriorations in the QoV over the 2-week periods of lens wear. Apart from potentially being more aware of such changes, it is possible that subtle, lens-induced changes in corneal shape, which would be expected to alter optical aberrations, and reductions in lens surface quality due to poor lens care, may have contributed to this reduction. Neither factor was systematically assessed in the current study. It is also possible that this decrease in QoV over time reflects, at least in part, increasing intolerance to any degradation in their vision among our student subjects.

There have been and are many ongoing product developments designed under the premise that imposed peripheral myopic defocus or simultaneous myopic defocus, achieved using progressive power profiles (Sankaridurg et al. 2011) and/or concentric designs (Anstice & Phillips 2011; Lam et al. 2014), reduces myopia progression. The Proclear MF SCL has traditionally been prescribed for correction of presbyopia, but it is increasingly being used in clinical practice as a myopia control therapy. This design

Table 3. p-values of statistical comparisons of visual symptoms with SV SCLs at BL, and with the lower add MF1.5 and higher add MF3 SCLs, at SV1 and SV2.

Symptom	MF1.5			MF3		
	BL versus SV1	BL versus SV2	SV1 versus SV2	BL versus SV1	BL versus SV2	SV1 versus SV2
Glare						
Frequency	0.655	0.005*	0.001*	0.017	<0.001*	<0.001*
Severity	0.705	0.033	0.002*	0.058	0.001*	0.001*
Bothersome	0.564	0.083	0.008*	0.029	<0.001*	<0.001*
Halos						
Frequency	0.564	0.013*	0.014*	0.041	<0.001*	<0.001*
Severity	0.564	0.013*	0.014*	0.038	<0.001*	0.001*
Bothersome	0.157	0.011*	0.034	0.02	<0.001*	0.001*
Starbursts						
Frequency	0.157	0.046	0.023	>0.999	<0.001*	<0.001*
Severity		0.156		0.655	0.001*	<0.001*
Bothersome		0.174		>0.999	0.001*	0.001*
Hazy vision						
Frequency		0.282		0.001*	<0.001*	0.615
Severity		0.255		0.002*	0.002*	0.49
Bothersome		0.141		0.002*	0.002*	0.792
Blurred vision						
Frequency	0.025	0.002*	0.097	<0.001*	<0.001*	0.346
Severity	0.132	0.005*	0.021	<0.001*	<0.001*	0.378
Bothersome	0.257	0.002*	0.003*	<0.001*	<0.001*	0.059
Distortion						
Frequency		0.368			0.072	
Severity		0.368		0.157	0.014*	0.157
Bothersome		NA			0.135	
Double vision						
Frequency		0.055		0.054	0.031	0.414
Severity		0.066		0.053	0.03	0.414
Bothersome		0.05		0.084	0.026	0.157
Fluctuation in vision						
Frequency	0.705	0.008*	0.026	<0.001*	<0.001*	0.033
Severity	0.257	0.005*	0.059	<0.001*	<0.001*	0.157
Bothersome	>0.999	0.013*	0.019	<0.001*	<0.001*	0.109
Focusing						
Frequency		0.205		0.003*	<0.001*	0.132
Severity		0.469		0.002*	0.001*	0.275
Bothersome		0.431		0.003*	<0.001*	0.196
Depth perception						
Frequency		0.513		0.257	0.02	0.145
Severity		0.247		0.564	0.033	0.052
Bothersome		0.692			0.082	

* Statistical significance, with an adjusted critical p-value of 0.0167.

includes a central zone incorporating the distance correction and a peripheral near addition zone that imposes myopic defocus onto the peripheral retina. However, this design also adds positive spherical aberration (Tarrant et al. 2008), which is likely to affect the central vision of younger subjects more than older subjects, because of their relatively large natural pupils. Indeed, the relatively small size centre zone (2.3 mm) of the Proclear MF SCL ensures multifocality in the pupil zone for most young subjects and at most distances, given that they also show reduced near pupillary responses (Kasthurirangan & Glasser 2006). A reduction in the quality of vision relative to that offered by SV lenses is thus predicted, as is greater impairment with higher compared to lower adds, as observed in the current study. Poor vision, irrespective of its cause, has been associated with diminished quality of life and general functional living activities (Knudtson et al. 2005).

The only other study to investigate the effects of MF SCL on the quality of life of young wearers (children and adolescents), by Greiner (2009) made use of the Paediatric Refractive Error Profile (PREP) questionnaire, first applied by Walline et al. (2007) to examine the benefits of contact lenses generally over spectacles in terms of the quality of life of children and adolescents. This questionnaire aims to quantify the overall quality of life of young individuals affected by refractive errors, with only three of its 10 scales relating to vision. As in the current study, the distance centre Proclear MF lens design, with a + 2.00 near peripheral add, was used in the Greiner study. However, different from the results reported here, no significant differences between the MF and SV SCLs were found. Plausible explanations for this

difference in study outcomes include the limitations of the PREP questionnaire, in which has only three of 10 scales relate to vision. Perhaps more importantly, it also does not use equal interval-level scoring, as in the QoV questionnaire applied in the current study. Equal interval-level scoring weights scores according to their degree of difficulty, rather than assuming each interval step change is the same for all symptoms (Mallinson 2007). Thus, the QoV questionnaire represents a more sensitive tool than the PREP questionnaire and it also allows a more comprehensive assessment of the effects on the quality of vision of MF SCLs. Consequently, adverse effects on the quality of vision with MF SCLs were revealed in the current study, even with the low add (+1.50 D) used, compared to the negative results for the higher add (+2.00 D) used in the Greiner (2009) study.

Although distance centre MF SCL designs are recognized to generally offer better distance vision than near centre MF lens designs (Bakaraju et al. 2012), the quality of vision offered by MF SCLs, data reported here indicate that even the former MF SCL designs reduce the quality of vision compared to that provided by SV SCLs, more so with high adds. It is important for clinicians prescribing MF SCLs to be aware of their potential to negatively impact on vision, given that the quality of vision offered by the lenses will also influence the acceptance and compliance of the wearers, especially as it has also been suggested that greater myopic defocus, that is higher adds, are purported to offer better myopia control (Smith 2011). Thus, clinicians must weigh the benefit of increasing the add power of a MF SCL to potentially improve myopia control against the disadvantage of decreased quality of vision.

In summary, the results of this study indicate that MF SCLs reduce the quality of vision relative to that offered by SV SCLs, increasingly so when the add is increased, and furthermore, that high-contrast VA is not a very sensitive measure of visual quality. Future clinical trials testing the efficacy of multifocal lenses for myopia control should consider including both low-contrast VA testing and the current QoV questionnaire, as administered in the study, or an equivalent test, to better

characterize the effects on vision of such lenses and so to allow for more informed comparison of alternative treatment options.

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