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Visual performance of single vision and multifocal contact lenses in non-presbyopic myopic eyes

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ABSTRACT

Purpose: To assess visual performance of single vision and multifocal soft contact lenses.
Methods: At baseline, forty-four myopic participants (aged 18–35 years) were fitted bilaterally with a control lens (AirOptix Aqua). At the four follow-up visits, a total of 16 study lenses (5 single vision, 11 multifocal lenses) were fitted contralaterally. After 1 h of lens wear, participants rated (scale 1–10) vision clarity (distance, intermediate and near), magnitude of ghosting at distance, comfort during head movement, and overall comfort. Distance high contrast visual acuity (HCVA), central refraction and higher order aberrations, and contact lens centration were measured.
Results: For single vision lenses, vision ratings were not significantly different to the control ($p > 0.005$). The control outperformed Acuvue Oasys, Clariti Monthly and Night and Day in HCVA (mean VA: -0.10 ± 0.07 logMAR, $p < 0.005$). Most refraction and higher order aberration measures were not different between lenses. The Night and Day lens showed greatest differences compared to the control, i.e., C[4, 0] was more positive ($p < 0.005$) at distance ($\Delta = 0.019\ \mu m$) and near ($\Delta = 0.028\ \mu m$). For multifocal lenses, the majority of vision ratings (84%) were better with the control ($p < 0.005$). HCVA was better with the control ($p < 0.005$). Proclear Multifocal lenses showed greatest differences for M, C[3, −1] and C[4, 0] at distance and near, and were inferiorly de-centered ($p < 0.005$).
Conclusion: Design differences between single vision lenses had a small impact on visual performance. Lenses featuring multifocality decreased visual performance, in particular when power variations across the optic zone were large and/or the lens was significantly de-centered.

1. Introduction

Myopia is the most common eye disorder, affecting an estimated 1.45 billion people worldwide. Due to its increasing global prevalence [1] and its associated risks in causing eye diseases, such as glaucoma [2], cataract [3] and retinal detachment [4], myopia has become a major public health concern.

Single vision contact lenses are a widely used optical treatment strategy for the correction of myopia. Although primarily aimed to provide clear central vision by correcting the lower order aberrations of defocus and astigmatism, their optical designs vary in their united attempt to improve optical performance. Most commonly prescribed commercially available single vision contact lenses exhibit a degree of negative spherical aberration [5]. Although the contribution of higher order aberrations on visual performance is generally small, negative spherical aberration has shown to improve high- and low-contrast visual acuity [6]. To our knowledge no studies have yet assessed whether single vision contact lens wearers can perceive visual differences when comparing commercially available contact lens designs.

Besides single vision contact lens correction, reported associations between myopia and accommodative lag [7–10], and between peripheral vision and the onset of myopia progression [11,12] have increased the interest in developing and testing special contact lenses for myopia treatment. Specifically, such lenses aim not only to provide foveal distance vision correction but also to slow the rate of myopia progression by inducing some degree of multifocality in their optical design. Such lenses not only include the plethora of commercially available bi- and multifocal contact lenses but also novel lens designs, including the marketed myopia control contact lens MiSight, which features a large central distance zone surrounded by alternating concentric distant and

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near zones. Various commercial and novel multifocal contact lenses have been assessed for the capacity to retard myopia progression [13–17], however, few studies have assessed the visual performance of multifocal contact lenses in non-presbyopic myopic eyes [18–20]. The accumulated evidence from these studies indicates some degradation of visual performance is likely to occur when contact lenses with multiple refractive zones are worn. However, those studies were limited in that they only assessed two or three different lens types per study and the work by Shah and Gundel, and Montes-Mico and co-workers used only objective measures to compare different lens types. Kollbaum and co-workers however showed that although there were no differences in distance high contrast visual acuity (HCVA) between habitual vision correction and a center-distance multifocal lens and the MiSight lens, the subjective responses were significantly worse with the test lenses. These observations suggest that contact lens wearers may perceive quality of vision differently when performing activities in real world than what acuity-based measures are able to capture.

Based on the limited information on visual performance with currently available contact lenses, the primary objective of this study was to provide an overview on subjective vision responses from non-presbyopic myopic participants wearing the most commonly prescribed single vision and multifocal contact lenses. In addition to subjective responses, objective measures such as high-contrast visual acuity, central refraction and higher-order aberrations, as well as contact lens centration were measured. In face of the current understanding of myopia correction and control options, the visual performance information provided from this study can aid practitioners in fitting the most appropriate contact lens type.

2. Methods

This was a prospective, participant-masked, contralateral, controlled, balanced block design clinical trial conducted at the Brien Holden Vision Institute (Sydney, Australia). The protocol and informed consent were reviewed and approved by an independent ethics committee and the research followed the tenets of the Declaration of Helsinki. Informed consent was obtained from all participants after explanation of the nature, procedures, and consequences of the study and participants were free to withdraw at any time without obligation. The study was registered with the Australian and New Zealand Clinical Trial Registry (ACTRN12612000370808) prior to enrolment of the first participant.

2.1. Participants

The inclusion criteria of the study included myopia between −0.25D to −4.00D and astigmatism of no greater than −1.00DC. The age group chosen for this study was 18–35 years, which is older than the age group for which myopia control therapies will most likely been used for. However, due to difficulties in recruiting the required sample size of myopic children in Sydney, the inclusion criteria was limited to non-presbyopic myopic adults. Exclusion criteria included any ocular disease or systemic disease that would contraindicate contact lens wear, previous eye surgery within 12 weeks prior to enrollment, use of any ocular or systemic medication likely to alter normal ocular findings. Previous contact lens wear was not a requirement. For each participant, five scheduled visits (including the baseline visit) were required to complete the study, with a minimum of an overnight wash-out between the visits. Participants were asked to wear their own habitual correction during the wash-out period.

Once trial suitability was established at the baseline visit, participants were fitted bilaterally with the single vision control lens Air Optix Aqua. This lens was chosen due to its minimal spherical aberration [5] and thus, minimal impact on vision changes across the optical zone. Following the baseline visit, each participant was asked to attend four follow-up visits, where a total of 16 test lenses (i.e., four lenses per visit) were fitted contralaterally as per randomisation. Specifically, at each follow up visit, the participant was first fitted with one test lens in each eye, after which all study procedures were performed monocularly and subsequently a second test lens was fitted in each eye and tested. Study procedures were always performed 1 h after lens wear. For all lenses, the lens power was selected based on the spherical equivalent of the distance subjective refraction performed at the baseline visit with the control lens and adjusted for

Table 1
Details of contact lenses used in the study.

	Lens design	Contact lenses	Manufacturer	Material	Diameter (mm)	Base curve (mm)
Control lens	Single vision	AIR OPTIX® AQUA	Alcon	Lotrafilcon B	14.2	8.6
Test Lenses	Single vision	ACUVUE® OASYS®	Johnson & Johnson	Senofilcon A	14.0	8.4
	Single vision	Biofinity®	Cooper Vision	Comfilcon A	14.0	8.6
	Single vision	Clariti™	Sauflon Pharmaceuticals	Filcon II 3	14.1	8.4
	Single vision	Night and Day™	Alcon	Lotrafilcon A	13.8	8.6
	Single vision	Proclear®	Cooper Vision	Omafilcon A	14.2	8.6
	Active control technology	MiSight®	Cooper Vision	Omafilcon A	14.2	8.7
	Concentric bifocal	ACUVUE® Bifocal High Add power	Johnson & Johnson	Etafilcon A	14.2	8.5
	Concentric bifocal	ACUVUE® Bifocal Low Add power	Johnson & Johnson	Etafilcon A	14.2	8.5
	Center-near multifocal	AIR OPTIX® AQUA MULTIFOCAL High Add power	Alcon	Lotrafilcon B	14.2	8.6
	Center-near multifocal	AIR OPTIX® AQUA MULTIFOCAL Low Add power	Alcon	Lotrafilcon B	14.2	8.6
	Center-distance multifocal	Proclear® Multifocal High Add power (Design D)	Cooper Vision	Omafilcon A	14.4	8.7
	Center-distance multifocal	Proclear® Multifocal Low Add power (Design D)	Cooper Vision	Omafilcon A	14.4	8.7
	Center-near multifocal	Proclear® Multifocal High Add power (Design N)	Cooper Vision	Omafilcon A	14.4	8.7
	Center-near multifocal	Proclear® Multifocal Low Add power (Design N)	Cooper Vision	Omafilcon A	14.4	8.7
	Center-near multifocal	PureVision® Multi-Focal High Add power	Bausch & Lomb	Balafilcon A	14.0	8.6
	Center-near multifocal	PureVision® Multi-Focal Low Add power	Bausch & Lomb	Balafilcon A	14.0	8.6