

# Visual performance of new affordable and auto-adherent lenses for presbyopia correction

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## Abstract

Presbyopia is a visual condition that affects all of us, evolving with time, reducing the range of accommodation and the ability to work at near. Reading glasses, bifocals or multifocal lenses are the most common solutions. In this work, we demonstrate the near visual performance of new elastomeric auto-adherent lenses developed for the correction of presbyopia. Visual acuity and contrast sensitivity were measured in 10 presbyopic subjects. The results showed that wearing either conventional trial ophthalmic lenses or the new elastomeric lenses provided similar visual quality. These elastomeric lenses can be placed in, or removed from the distance-vision spectacles of the wearers, providing an affordable solution for correcting presbyopia at its clinical onset, which might be especially useful in subjects with different refractive error in each eye and for those with astigmatism.

## KEYWORDS

auto-adherent lenses, contrast sensitivity, presbyopia, visual acuity

## INTRODUCTION

Presbyopia is a progressive eye condition characterised by near-vision impairment (VI) due to an alteration in the accommodation system. Presbyopic symptoms usually appear between 40 and 50 years of age. Patients typically report difficulties seeing objects clearly at intermediate and near distances, and symptoms worsen with age. They will have problems performing intermediate (e.g., working with desktop computers) and near (e.g., reading or sewing) tasks, which will have an impact on working productivity and quality of life.<sup>1</sup>

In 2015, it was estimated that between 1.7 and 2.0 billion people had presbyopia, but the prevalence is expected to increase due to the ageing global population.<sup>2</sup> Among those with presbyopia, around 826 million suffered VI due to wearing an inadequate or no near visual correction. In fact, despite the different options that exist to correct presbyopia (e.g., single vision reading glasses, multifocal spectacle lenses, contact lenses or intraocular lenses),<sup>3</sup>

uncorrected or mis-corrected presbyopia is one of the leading causes of VI worldwide.<sup>4</sup>

The number of people not wearing an appropriate presbyopia correction is much higher in low-income countries.<sup>2</sup> It was estimated that 50% of individuals >50 years of age in developing countries do not have their presbyopia corrected, in part due to the lack of affordable visual correction options.<sup>5</sup> To cope with that scenario, the 'Universal Eye Health: A Global Action Plan 2014–2019' set by the World Health Organization in 2013 considered the development of low-cost and easy-to-use optical corrections for presbyopia, a global priority to reduce the prevalence of avoidable VI.<sup>6</sup> In addition, those resources could achieve productivity gains of US\$ 1.05 trillion by 2050.<sup>7</sup> Following that line of thinking, our research group has devised new auto-adherent lenses for the correction of presbyopia suitable to be placed on top of the distance correction. This option is cheaper than buying reading or multifocal lenses. Considering that presbyopia is a progressive condition, the auto-adherent

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lenses will make it easier for low-income patients to acquire updated addition lenses at affordable prices. Auto-adherent lenses, also known as 'press-on' lenses, can adhere to ophthalmic lenses thanks to Van der Waals forces and pressure. In general, a few drops of water are helpful to achieve good adherence. Since that the forces involved in the adherence process are weak, these auto-adherent lenses can be removed easily without damaging the surface of the ophthalmic lenses.

Currently, there are auto-adherent lenses having the shape of typical bifocal segments on the market. These segments allow presbyopes to convert a monofocal ophthalmic lens into a bifocal lens (see Figure 1). On e-commerce platforms, we were able to find several segments, with Hydrotac, distributed by Optx, being the best known ([optxeurope.com/es/](http://optxeurope.com/es/)). These near addition segments are commercially available with refractive power ranging from +1.25 to +3.00 D. Hydrotac are made from transparent rubber and need the use of a few drops of water and pressure to achieve good adherence to the ophthalmic lens. Although these segments have been on the market for several years, little information is available about their optical quality. In fact, one recent study showed that these lenses can induce astigmatism up to 0.75 D.<sup>8</sup> This may be due to inadequate adhesion of the segment to the ophthalmic lens, possibly related to the relatively low elasticity of the material used for their fabrication. No studies were found assessing their visual performance, which is a limitation if eye care professionals are considering prescribing this visual aid.

Accordingly, new auto-adherent lenses for the correction of presbyopia have been developed by our research group.<sup>8</sup> These auto-adherent lenses have the same size as the entire ophthalmic lens, thus converting a distance ophthalmic lens into a near-vision lens, rather than a bifocal. This minimises potential rejection by the patient for aesthetic reasons. It also allows a larger visual field for near vision and eliminates the image jump that can take place with bifocal lenses when switching gaze from distance to near vision. A major benefit of these lenses, in contrast to over the counter reading glasses, is that presbyopic patients can place the auto-adherent lenses, incorporating the necessary near addition, on top of their distance vision ophthalmic lenses. Ready-made spectacles, while an affordable option, are manufactured with



**FIGURE 1** Spectacles with Hydrotac segments adhered.

### Key points

- Elastomeric auto-adherent lenses can be a solution to improve near vision in presbyopia.
- Elastomeric auto-adherent lenses provide similar visual acuity and contrast sensitivity to conventional trial lenses used in clinical practice.
- Elastomeric auto-adherent lenses are an affordable solution for subjects with different refractive errors in each eye and those with astigmatism for whom over-the-counter reading glasses are not an appropriate solution.

the same prescription in each eye, and are only available in spherical plus powers. With auto-adherent lenses, patients requiring a different optical prescription in each eye, as well as those with astigmatism, will have an appropriate near-vision correction. Further, this option is cheaper than buying new reading or multifocal spectacles. Hence, these new auto-adherent lenses have the potential to minimise the cost to achieve satisfactory near vision for presbyopes. Considering that presbyopia is a progressive condition, auto-adherent lenses allow low-income patients to update their near addition as required.

For a previous study,<sup>8</sup> our research group manufactured auto-adherent elastomeric lenses which were measured with a wavefront sensor and focimeter. In addition, we assessed the image quality provided by these lenses using an artificial eye, with the lenses exhibiting good optical quality and minimal aberrations.<sup>8</sup> However, these new auto-adherent lenses were not tested in presbyopic subjects. Therefore, in considering the potential impact of these lenses to eradicate VI due to uncorrected presbyopia, the purpose of this study was to evaluate whether the near visual performance of these lenses was similar to that of conventional trial lenses. Therefore, visual acuity (VA) and contrast sensitivity (CS) were evaluated at near in a cohort of 10 presbyopic subjects using both auto-adherent and conventional trial lenses.

## MATERIALS AND METHODS

Ten healthy subjects with a mean age of  $54.5 \pm 6.6$  years (range: 48–63 years) were included in this study. Five (50%) subjects were male and five (50%) were female. Four of the participants did not need distance visual correction, three were myopic and three had a combination of myopia with astigmatism (all with astigmatism > 1.00 DC).

This study followed the tenets of the Declaration of Helsinki. All subjects signed a consent form after a full explanation of the study. Data were pseudonymised, giving a code to each participant. Ethics approval was granted

by the University of Santiago de Compostela Bioethics Committee (Santiago, Spain).

## Methods

Polydimethylsiloxane (PDMS) auto-adherent lenses with differing plus powers (i.e., +1.00, +2.00 and +3.00D) were manufactured following the protocol described previously.<sup>8</sup> PDMS is an optically transparent silicone elastomer; biocompatible with good durability and thermal stability within a wide range of temperatures (from  $-45$  to  $+200^{\circ}\text{C}$ ).

The auto-adherent lenses were cut to the shape of the one of conventional trial lenses. A code was written on each lens to ensure we were using the desired near addition (add). Each auto-adherent lens was placed on top of a plano trial lens (Figure 2). This ensured subjects were masked regarding the lens type being tested.

Distance VA was measured with the habitual distance prescription, when needed. A CC-100 screen (Topcon Healthcare Solutions: [topconhealthcare.eu](http://topconhealthcare.eu)) placed at 4m was used. When participants did not achieve VA of 0.00 LogMAR or better with their habitual prescription, then a subjective refraction was performed by a qualified optometrist.

To assess near vision, the distance prescription of each subject (when needed) was placed in a trial frame. Then, depending on the age and habitual near-working distance, a near add was selected (+1.00, +2.00 or +3.00 D). The same add was introduced using both conventional trial lenses and auto-adherent lenses. The presentation of the different lenses followed a random order, and all subjects were masked regarding the lens type being used. Validated optotypes, from Optonet Vision Unit (OVU: [optonet.com.es/](http://optonet.com.es/)), were presented on an iPad ([Apple.com](http://Apple.com)—see Figure 3). Subjects were asked to hold the iPad at their desired near distance. Near VA was measured using the 'Reading test' and CS with the 'Contrast test' included in the OVU. The CS test is similar to the conventional Pelli-Robson chart in that it uses a single large



**FIGURE 2** Example of the lenses used. Plano trial lens with the auto-adherent lens (left), and conventional trial lens (right).

letter size ( $1 \times 1$  cm), with contrast decreasing across groups of three letters. The score obtained was based on the contrast of the last group where all three letters were read correctly. Higher values indicate better CS function (range 0.05–2.30 LogCS). Monocular and binocular measurements were performed for both VA and CS. All tests were performed under photopic conditions (44 lx and CCT 5300 K at the corneal plane) by the same qualified optometrist.

## Data analysis

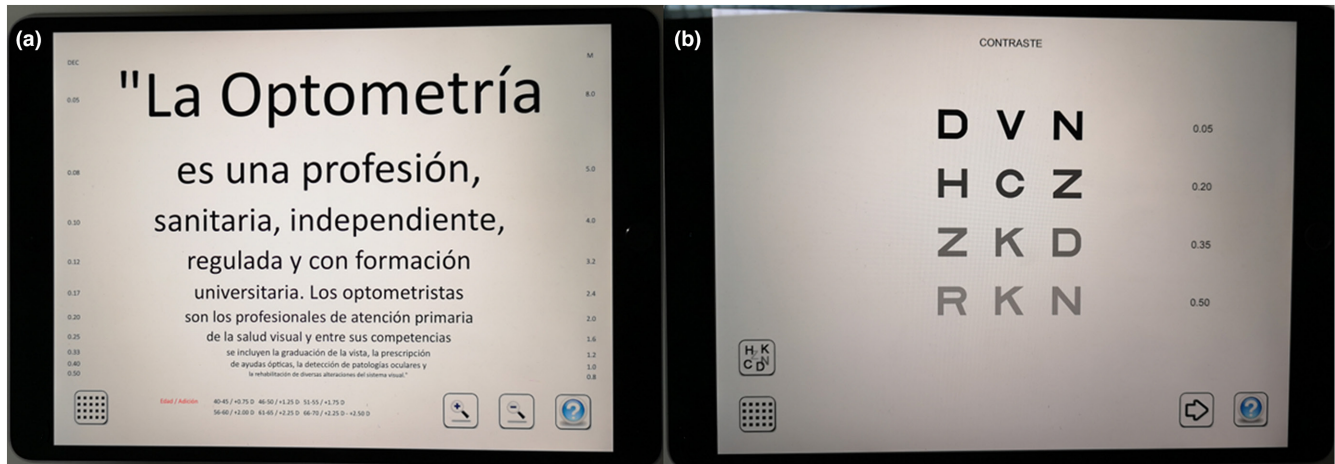
Data analysis was performed with SPSS Statistics version 28.0 ([ibm.com](http://ibm.com)). The Shapiro–Wilk test was used to assess the normal distribution of the data. A dependent *t*-test was used to compare the results obtained with the two types of lenses.  $p \leq 0.05$  was considered statistically significant.

## RESULTS

Table 1 shows that the near VA achieved with the auto-adherent and conventional trial lenses were exactly equal, with all subjects able to read 0.0 LogMAR text under both monocular and binocular conditions at their desired near-working distance (ranging from 25 to 40 cm). Near CS with auto-adherent lenses was also similar to that obtained with conventional trial lenses ( $p > 0.99$ ). As shown in Table 1, CS was slightly better under binocular compared with monocular conditions for both types of lenses. After testing, subjects were asked about their subjective experience and all reported being comfortable with both types of lenses.

## DISCUSSION

To our knowledge, this is the first time that the near visual experience provided by auto-adherent lenses has been evaluated. This study showed that near high-contrast VA and CS achieved with the new auto-adherent lenses were similar to those obtained with conventional trial lenses, which are commonly used in clinical practice to determine the near addition for presbyopes. This confirms the good optical performance of these new lenses. It is important to highlight that having a high level of CS is important when performing tasks under mesopic and scotopic conditions, and the results of the present study show that the auto-adherent lenses provided optimal visual performance, even under dim conditions. While the results of the present study are very promising from a visual point of view, the auto-adherent lenses also presented some limitations in terms of handling and susceptibility to soiling. The PDMS material is prone to attract dust. Also, the placement of the auto-adherent lenses on top of the ophthalmic trial lenses



**FIGURE 3** Near-vision tests: (a) Reading test and (b) contrast sensitivity test.

**TABLE 1** Values of visual acuity (VA) and contrast sensitivity (CS) obtained monocularly and binocularly with each type of lens (mean  $\pm$  standard deviation).

	RE	LE	BE	p-Values	
				RE vs. BE	LE vs. BE
VA (LogMAR)					
Trial lenses	0.0 $\pm$ 0.1	0.0 $\pm$ 0.1	0.0 $\pm$ 0.1		
Auto-adherent lenses	0.0 $\pm$ 0.1	0.0 $\pm$ 0.1	0.0 $\pm$ 0.1		
CS (LogCS)					
Trial lenses	2.0 $\pm$ 0.1	2.0 $\pm$ 0.1	2.1 $\pm$ 0.1	0.004	<0.001
Auto-adherent lenses	2.0 $\pm$ 0.1	1.9 $\pm$ 0.1	2.1 $\pm$ 0.1	0.004	<0.001

Abbreviations: BE, both eyes; LE, left eye; RE, right eye.

had to be done carefully to obtain a transparent surface and prevent the subjects from experiencing foggy vision. Therefore, although the visual performance was good, more work is needed to improve the properties of the material to facilitate their handling before moving to a more ambitious trial involving daily use of the new auto-adherent lenses.

Regarding the expected use of these new auto-adherent lenses, it is important to bear in mind that they need to be placed on top of the monofocal distance lens (or plano spectacles for emmetropic subjects). This provides an affordable solution to produce an appropriate near-vision correction, even in patients with astigmatism or those with different prescriptions in each eye. This is an important advantage compared to ready-made spectacles for presbyopia because they are only available with the same spherical power in both eyes.<sup>9</sup>

An interesting characteristic of the auto-adherent lenses is that they can be used for a short period of time. In this regard, if an individual performs several tasks at different distances (e.g., playing a musical instrument, reading a book or sewing), they could use auto-adherent lenses with different add powers, changing them to adapt to their desired working distance. When

compared to conventional multifocal lenses, auto-adherent lenses have the limitation that patients do not have a single lens for all distances, but do present the advantage of a larger area for near vision. With multifocal spectacle lenses, patients need to adjust their head and eye movements to ensure they are looking through the correct zone of the lens, otherwise, their vision will be blurred. Therefore, although the auto-adherent lenses present their own limitations, they are an affordable alternative to multifocal lenses. In this regard, auto-adherent lenses have the potential to help eradicate the near VI due to uncorrected presbyopia, particularly in developing countries where costs are an important limitation in its correction.<sup>5</sup>

Finally, considering that the auto-adherent lenses allow temporary use, and they could be manufactured with higher powers without a significant increase in weight, these lenses could be used for purposes other than the correction of presbyopia. For instance, they could be used by low-vision patients, who often require different powers to perform a range of tasks. Auto-adherent lenses could be an affordable alternative for these patients, but further studies are needed to explore this possibility.



## CONCLUSION

The new auto-adherent lenses tested here provided good VA and CS for presbyopic patients. They are an affordable solution for patients with different distance prescriptions in each eye, as well as those with astigmatism. Further work is needed to improve the properties of the lens material and evaluating their visual performance in daily use.

## AUTHOR CONTRIBUTIONS

**Nery Garcia-Porta:** Conceptualization (lead); data curation (lead); formal analysis (lead); funding acquisition (equal); investigation (lead); methodology (lead); resources (equal); supervision (equal); validation (equal); visualization (lead); writing – original draft (lead); writing – review and editing (lead). **Ana I. Gómez-Varela:** Conceptualization (equal); funding acquisition (equal); investigation (equal); methodology (equal); resources (lead); supervision (equal); validation (equal); writing – original draft (equal); writing – review and editing (equal). **Justo Arines-Piferrer:** Conceptualization (equal); data curation (equal); formal analysis (equal); funding acquisition (equal); investigation (equal); methodology (equal); resources (equal); supervision (lead); visualization (equal); writing – original draft (equal); writing – review and editing (equal).

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## CONFLICT OF INTEREST STATEMENT

The authors do not have any financial or proprietary interest in any material or method mentioned.

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