The potential future of contact lenses in the low vision clinic

By Mia Shergill BSc (Hons) **and**

Dr Elizabeth Bartlam DOphSc BSc (Hons) FBDO (Hons) LVA SFHEA

The dispensing optician has the opportunity to both develop their low vision practice, and train to become a qualified contact lens optician. At times, there will be instances where a low vision patient is best managed by the use of contact lenses. Contact lenses have been found to be effective in slowing down the progression of myopia, and are used in cases of keratoconus, as well as in cases where the iris is impacted — including iris coloboma and aniridia. There has also been research and innovation aimed at addressing the challenges faced by those with other pathologies found within the low vision clinic.

This article explores some of the exciting developments that may influence the future of contact lens practice in the low vision clinic, enabling clinicians to address patients' visual pathologies beyond those traditionally considered for contact lenses. These developments could potentially lead to contact lens practice being incorporated into a low vision clinic – or vice versa – enabling patients to be more successfully managed.

LOW VISION

The term low vision applies to individuals who have reduced functional vision beyond refractive correction, treatment or surgery, which affects their day-to-day lives, according to the UK Low Vision Service Consensus Group[1]. The World Health Organisation defines this term based on a specific level of vision, from 6/18 to light perception, or a visual field less than 10° from the point of fixation[2].

The leading causes of low vision are shown in **Figure 1**, however, various conditions can be found within a low vision clinic.

The Royal National Institute of Blind People (RNIB) states that more than two million people in the UK have some form of sight loss that impacts significantly on their daily life, with 24,000 people each year issued a Certificate of Vision Impairment[3]. There are approximately 340,000 people registered as sight impaired or severely sight impaired in the UK – although not all those who are eligible are registered.

As the population ages, the importance of care provision will increase. This will result in increased demand for low vision services to help people utilise their functional vision to carry out their daily tasks, to allow independence and improve their quality of life[4].

Many of the conditions shown in **Figure 1** are not amongst those for which contact lenses might be traditionally considered beneficial, with age-related macular degeneration (AMD) being the most prevalent. Therefore, it may be concluded that only a small number of visually impaired patients are considered for contact lenses – with the vast majority managed by more traditional methods, such as magnifiers.

LIMITATIONS OF OPTICAL AIDS

Conventionally in low vision clinics, optical aids such as magnifiers and telescopes are used to increase the area of the retina that the image falls on, so that it can be better detected by the functional area of the retina[5].

LEARNING DOMAINS

CLINICAL PRACTICE

SPECIALTY: CONTACT LENS OPTICIANS

COMMUNICATION

PROFESSIONAL GROUPS

Dispensing opticians — CPD PROVIDER — General Optical Council

Optometrists — CPD PROVIDER — General Optical Council

Contact lens opticians — CPD PROVIDER — General Optical Council

CPD CODE: C-107933

MCQs AVAILABLE ONLINE: Monday 1 April 2024

CLOSING DATE: 8 July 2024

ANSWERS PUBLISHED: September issue 2024

This CPD session is open to all FBDO members and associate member optometrists. Successful completion of this CPD session will provide you with a certificate of completion of one non-interactive CPD point. The multiple-choice questions (MCQs) are available online from Monday 1 April 2024. Visit www.abdo.org.uk After member login, scroll down and you will find CPD Online within your personalised dashboard. Six questions will be presented in a random order. Please ensure that your email address and GOC number are up-to-date. The pass mark is 60 per cent.

CPD CODE: C-107933

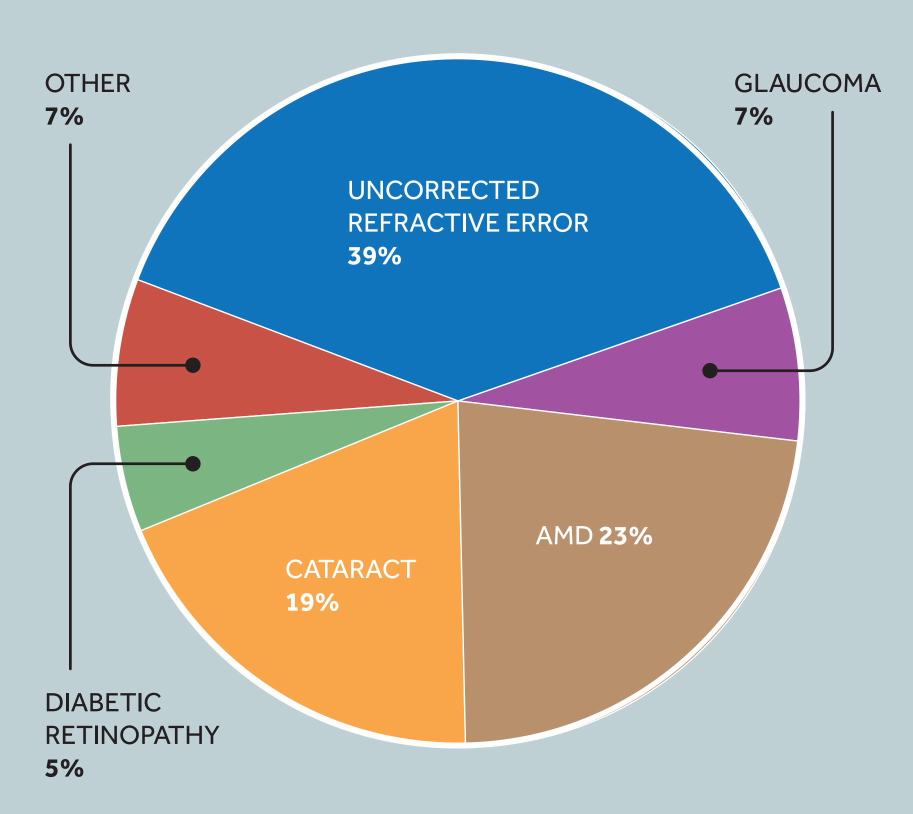

FIGURE 1. Leading causes of sight loss within the UK as of 2021
(data compiled and adapted from RNIB Key statistics about sight loss 2021. p.12)

This is particularly useful for patients with conditions that affect the central visual field, such as AMD, as it uses the residual vision the patient does have more effectively so they can carry out their day-to-day tasks. However, the efficacy of these aids can be limited by design trade-offs, such as between magnification and field of view as well as off-axis aberrations and unwanted reflections, which can limit the user's visual acuity[6].

USE OF CONTACT LENSES

Contact lenses can be prescribed to improve visual performance in areas that conventional low vision aids and spectacles cannot. They can improve the retinal image by removing some of the limitations of spectacles, such as minification for the high myope, and provide superior optics due to the optical centre of the lens moving with the eye. This limits off-axis aberrations and provides a wider field of view – as well as better cosmesis[7]. Contact lenses can also help with glare management.

In recent decades, there has been a rise in innovative ideas for the use of contact lenses[8]. They have the potential to provide the basis for future technologies that take low vision aids one step further in addressing a low vision patient's visual needs, and mitigating against current design trade-offs.

CONTACT LENS INNOVATIONS

ARTIFICIAL IRIS CONTACT LENSES

A recently developed smart artificial iris platform encapsulated in a scleral contact lens aims to go one step further than conventional tinted lenses to treat conditions such as aniridia, addressing blur and high order aberrations to provide better visual outcomes. This is achieved with real-time responses that involve a variable-pupil aperture that adapts to lighting and allows for greater depth of focus.

Quintero *et al*[9] carried out pre-clinical testing with simulated pupil and iris function in aniridia to test the performance of the optical quality of the smart artificial iris contact lens, compared to no optical correction of an eye with aniridia and with correction by a conventional scleral contact lens.

This technology is embedded into a scleral contact lens to limit interaction with the limbal zone and reduce the effects of lens wear on the tear film, as dry eyes and limbal stem cell failure are associated with aniridia[10]. The authors found encouraging results with the smart artificial iris contact lens, including a reduction in higher order aberrations[9].

SWITCHABLE TELESCOPE CONTACT LENSES

First explored in 1936, the use of contact lenses in conjunction with spectacles to create a Galilean telescopic system involved placing a high minus powered scleral contact lens (concave eyepiece lens) on the eye – with high positive powered lenticular spectacles (convex objective lens) worn to create an upright magnified image.

In addition, a further application of a telescope contact lens system would aim to minify the image using a positive eyepiece and negative objective lens for those with peripheral visual field defects, for example, glaucoma and retinitis pigmentosa patients. This minification allows more of the world being viewed to be fitted into the functional area of the retina. However, an obvious disadvantage of this is that minification also results in a reduction in visual acuity.

Soft lens materials provide improved comfort but due to the high power, causes challenges with fitting. Moreover, soft lenses reduce stability, therefore, modern rigid gas permeable and scleral lenses produce a more optimal outcome for the wearer. Sealed scleral lenses maximise stability to reduce induced prismatic effect caused by blinking and lid attachment with high powered contact lenses[10].

A key limiting factor is the magnification that can be achieved. The practical limit of the power of the contact lens would potentially be around -50D, requiring a back vertex distance of 20mm (the focal points of the objective and eyepieces need to coincide for afocal setting) and +25D spectacle lens. This would create a magnification that is limited to 2x due to the trade-off between a practical vertex distance, which is still very large, and reasonable powered lenses[7].

This system also creates vestibular conflict where any movement of the head will cause the image to move in the opposite direction, and wearers may experience difficulty in judging apparent depth. These limitations have prevented this device from being accepted and have hindered its success. However, there has been research that has looked at how this concept can be adapted to be more useful and practical for the sight impaired[11-13].

There have been some studies[11-13] exploring the use of a switchable telescope contact lens to provide magnified and non-magnified vision. Tremblay *et al*[13] were the first to create a prototype of their design of a switchable telescope contact lens of 1x and 2.8x magnification using internal reflection via mirrors. They found their design principles worked in providing dual magnification, however, the image quality produced was lower than anticipated.

Furthermore, their findings were based on a model eye and the oxygen permeability of the contact lens material used, polymethyl methacrylate, was poor. On this basis, Arianpour *et al*[12] went on to research a wearable form of this lens using the telescope optics embedded in a scleral lens, so that the sharp external edges were encased. However, with this design there was still surface roughness, which caused a reduction in resolution of the image produced.

Figure 2 shows this lens worn on one of the five subjects, as part of their small clinical study, although none had low vision. A key limitation of the lens was lack of oxygen permeability; limiting its wear time. They reported no problems in comfort and noticed the magnification difference when comparing the image size.

The results from this small study indicate potential for this optical design, however, the practicalities, particularly in terms of oxygen transmissibility, serves as a large limitation in the success of this particular device. Cosmesis of this device may also be a limiting factor. The current limitations may be why this early exploratory experimental trial has not made the transition into a developmental effort. However, this does not limit potential further experimental trials that may finally be viable to be developed.

AUGMENTED REALITY

Over the last decade there has been a particular interest in the use of augmented vision for those who are severely sight impaired, stemming from the world of virtual reality. The difference here is that modifications and enhancements are made to the real world, whereas virtual reality is a simulated

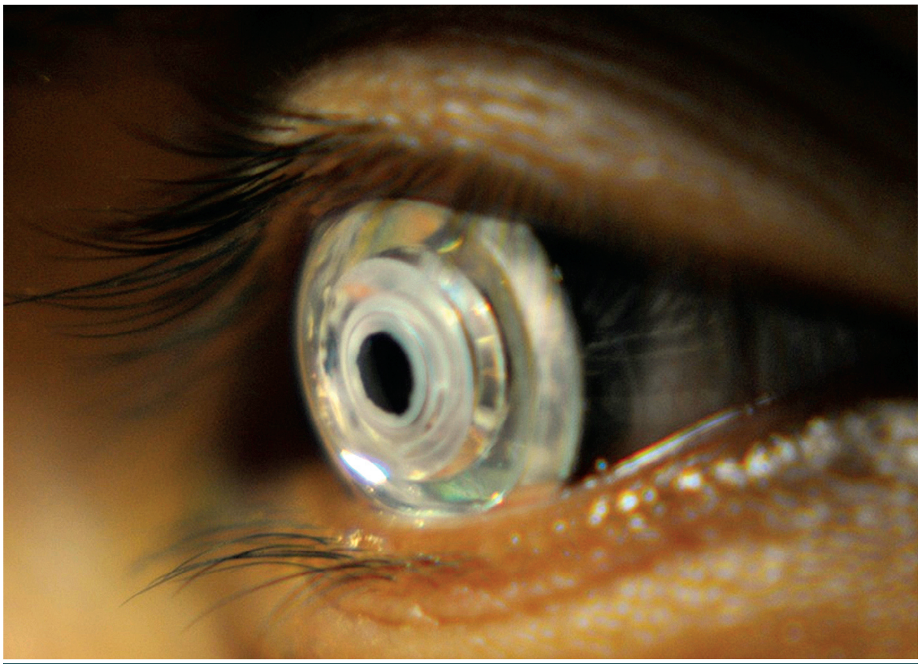

FIGURE 2. A participant wearing the switchable telescope contact lens, showing positive and negative annular concentric reflectors providing magnified vision while incorporating a clear aperture in the centre to produce a non-magnified image[12]

IMAGE: Reproduced by kind permission of Professor Joseph Ford, University of California, San Diego

environment[14]. This field is currently expanding with new research and ideas, and recent outcomes of this include commercial products and medical applications[15].

A major problem faced by those with low vision is navigation and recognition of objects, and the concept of augmented reality (AR) has been explored to tackle this issue. AR includes the use of visual cues, such as object outlines, to provide information of the wearer's surroundings[14]. This works by digitally enhancing the patient's vision in real time, including modifying magnification and contrast enabling edge visibility to allow those who are sight impaired to maximise their residual vision[16].

Alongside an increased field of view, these features can serve to aid mobility and situational awareness[17]. Furthermore, these devices are hands-free – and the user can customise their view of the world to be specifically adapted for their particular visual impairment[18].

HEAD-MOUNTED AR DEVICES

Head-mounted devices are currently the most common way of presenting AR vision to the user. Various AR head-mounted and smart glasses have been developed in the last few decades, some of which have adapted features to meet the needs of the low vision population.

Zhao *et al*[19] studied the effects of their head-mounted device ('Foresee') on 19 individuals with various sight impairments. Their device had enhancement features including magnification, contrast, edge enhancement, text contrast reversal and extraction as well as a visual field expander. The visual outcome was measured subjectively, based on the user's ability to perform the task. The customisation was found to be particularly useful as the participants were able to personally alter their view depending on their impairment and the task being performed. Key limitations identified were the device's bulkiness and cosmesis, based on participant feedback, as reported by Orlosky *et al*[15].

APPLICATION TO CONTACT LENSES

One way to address weight issues and improve the cosmesis of AR devices is to apply this technology to contact lenses. Another key advantage of AR contact lenses over spectacles is that the lens and image move with the eye meaning that eye tracking, using motion sensors, are very precise. This also provides a more natural way to present information without other physical devices such as headsets or magnifiers getting in the way of interactions and carrying out tasks, and so the field of view is maximised[20].

Research into augmented vision with contact lenses was carried out with a view that it could have potentially been a success of the future in aiding low vision patients to navigate their world. Adapting this concept from spectacles to contact lenses requires microchip technology to be implanted in the contact lens to achieve augmented vision[16].

However, there are major obstacles in producing a contact lens that can utilise this AR concept. Not only is it difficult to engineer technology that needs to be fitted on a small transparent lens, but it is also a challenge to produce a design that works wirelessly and can be powered somehow.

Despite this, Mojo Vision released its proposal of this concept whilst tackling these issues. The company invented its own micro-LED display that is under half a millimetre in size and centred over the pupil – allowing the AR to be maintained in any direction of gaze.

Mojo Vision intended to aim its first version of AR contact lenses at those with low vision to optimise residual vision by superimposing lines over the edges of objects that the wearer is looking at to aid detection. The technology is able to manipulate magnification and contrast, therefore, it can display text that is easier to read.

However, there were potential limitations to this device: the display image used green LED only and therefore limited blending in with the real-world. Furthermore, the device was not functional in bright light conditions, such as outdoors, as this requires increased brightness from the display in order for it to be visible, in contrast to the real world[16]. Clinical trials would be needed to study efficacy, but Mojo Vision's prototype has been worn on the human eye showing promising results, which bought it a step closer to commercialisation[21]. However, due to a lack of funding Mojo Vision has cancelled its AR contact lens and any further research.

IMPLEMENTING CONTACT LENSES INTO LOW VISION CLINICS

In addition to the visual benefits that contact lenses offer low vision patients, further practicalities need to be considered for their use in the low vision clinic. The costs and risks of contact lens wear should be considered, along with the safety profile of contact lenses for low vision individuals. Problems associated with contact lens wear can often be avoided with good compliance and hygiene.

The insertion and removal of contact lenses may be a particular challenge for an individual with low vision, and time-consuming initially, but studies have reported improvement with practice and that employing the use of a magnifying mirror and handling tints can be beneficial[10].

The practitioner should always take care to assess the suitability of contact lenses for the individual, and consider the likelihood of success during the initial consultation. It is also important to consider the need for an increased frequency of aftercare appointments, particularly for patients who already have impaired vision whereby an adverse event would be of high significance.

CONCLUSION

The future of contact lenses in low vision is both exciting and promising. Firstly, the needs of those with low vision are not always fully satisfied due to the limitations of conventional low vision aids. This necessity, coupled with an ageing population, may continue to spark interest and research.

Secondly, technological advancements in the general area of vision alongside contact lenses, such as microchip and battery advancements, could result in application of those technologies to contact lenses for use in low vision. Some of these technologies are no longer science fiction but nearing reality – and may go on to be implemented in contact lenses.

Thirdly, the pace and adoption of contact lenses in recent decades is likely to provide commercial drivers for innovation. The social acceptance and expectation of contact lenses will be a positive driver for change, especially in the next few decades as the current 50 to 60-year-old demographic are familiar with more modern technologies and aids – and may already be fitted with multifocal contact lenses. This increases the likelihood of future generations accepting contact lens-based low vision aids.

Dispensing opticians interested in this field may consider developing their skills further, and contact lens opticians and low vision opticians might consider developing both of these practice areas to ensure they have the skills and knowledge to manage their patients appropriately in the future.

MIA SHERGILL is a pre-registration optometrist, who graduated with a BSc (Hons in optometry from Aston University in 2023.

DR ELIZABETH BARTLAM is a teaching fellow, year three tutor, low vision module leader, admissions tutor and examinations officer at Aston University. She is a Doctor of Ophthalmic Sciences and qualified dispensing optician and low vision optician. She is a senior tutor and course writer for ABDO College, and external examiner for Birmingham City University, and a mentor for Canterbury Christ Church University.

REFERENCES

References can be found when completing this CPD module. For a PDF of this article with references, email abdocpd@abdo.org.uk

LEARNING OUTCOMES FOR THIS CPD ARTICLE

DOMAIN: Communication

1.6: *Consider where patients with low vision may have conducted research in advance of the consultation and appropriate communication regarding the relevance to their personal circumstances.*

DOMAIN: Clinical Practice

5.3: *Be aware of recent developments in the area of low vision and contact lenses, and consider how this may be relevant to your clinical patient care.*

7.5: *Provide effective patient care and treatments for patients with low vision based on current good practice.*

DOMAIN: CL Speciality

Consider how developments in contact lenses for patients with low vision may be relevant to the communication and clinical care you provide currently and how this may impact your potential future scope of practice.

References

1. The Royal College of Ophthalmologists. Guidance on low vision: the essential guide for ophthalmologists. www.rcophth.ac.uk/news-views/guidance-on-low-vision-2021 [Accessed 3 December 2022].

2. World Health Organisation. Blindness and vision impairment. 2021. www.who.int/news-room/fact-sheets/detail/blindness-and-visual-impairment [Accessed 3 December 2022].

3. RNIB. Key statistics about sight loss. 2021. www.rnib.org.uk/professionals/health-social-care-education-professionals/knowledge-and-research-hub/key-information-and-statistics-on-sight-loss-in-the-uk [Accessed 3 December 2022].

4. Stelmack J. Quality of life of low-vision patients and outcomes of low-vision rehabilitation. *Optom. Vis. Sci.* 2001;78(5):335-42.

5. Leat SJ, Fryer A, Rumney NJ. Outcome of low vision aid provision: the effectiveness of a low vision clinic. *Optom. Vis. Sci.* 1994;71(3):199-206.

6. Stevenson G, Gardner L. Progressive cone dystrophy, nystagmus and contact lenses. *Contact Lens Anterior Eye* 2010;33(5):28-30.

7. Byer A. Magnification limitations of a contact lens telescope. *Am. J. Optom. Physiol.* Opt. 1986;63(1):71-5.

8. Jones LW, Chauhan A, Di Girolamo N, Sheedy J, Smith E. Expert views on innovative future uses for contact lenses. *Optom.* Vis. Sci. 2016;93(4):328-35.

9. Quintero A, Pérez-Merino P, Fernández García AI, De Smet H. Smart contact lens: a promising therapeutic tool in aniridia. *Arch. Soc. Esp. Oftalmol.* (Engl Ed) 2021 Nov;96 Suppl 1:68-73.

10. Vincent SJ. The use of contact lenses in low vision rehabilitation: optical and therapeutic applications. *Clin. Exp. Optom.* 2017;100: 513-521

11. Tremblay E, Beer RD, Arianpour A, Ford JE. Telescopic vision contact lens. *Ophthalmic Technologies* XXI 2011 7885:10-18

12. Arianpour A, Schuster GM, Tremblay EJ, Stamenov I, Groisman A, Legerton J, Meyers W, Amigo GA, Ford JE. Wearable telescopic contact lens. *Appl. Opt.* 2015;54(24):7195-204.

13. Tremblay EJ, Stamenov I, Beer RD, Arianpour A, Ford JE. Switchable telescopic contact lens. *Opt. Express* 2013;21(13):15980-6.

14. Ehrlich JR, Ojeda LV, Wicker D, Day S, Howson A, Lakshminarayanan V, Moroi SE. Head-mounted display technology for low vision rehabilitation and vision enhancement. *American Journal of Ophthalmology* 2017;176:26-32

15. Orlosky J, Toyama T, Kiyokawa K, Sonntag D. ModulAR: eye-controlled vision augmentations for head mounted displays. IEEE *Trans. Vis. Comput. Graph.* 2015;21(11):1259-68.

16. Jones L, Hui A, Phan CM, Read ML, Azar D, Buch J, Ciolino JB, Naroo SA, Pall B, Romond K, Sankaridurg P, Schnider CM, Terry L, Willcox M. CLEAR Contact lens technologies of the future. *Contact Lens and Anterior Eye* 2021;44(2):398-430.

17. Bibby SA, Maslin ER, McIlraith R, Soong GP. Vision and self-reported mobility performance in patients with low vision. *Clin. Exp. Optom.* 2007;90(2):115-23.

18. Deemer AD, Bradley CK, Ross NC, Natale DM, Itthipanichpong R, Werblin FS, Massof RW. Low vision enhancement with head-mounted video display systems: are we there yet? *Optom. Vis. Sci.* 2018;95(9):694-703.

19. Zhao Y, Szpiro S, Azenkot S. ForeSee: A customisable head-mounted vision enhancement system for people with low vision. Association for Computing Machinery 2015:239-249.

20. Martin PS. Mojo vision nanoLEDs for Invisible computing. *SPIE Proceedings* 2020:11302.

21. Wiemer, M. Mojo Vision: designing anytime, anywhere AR contact lenses with Mojo lens. *Proc. SPIE;*2021:11764.