The quest for the ultimate contact lens

Dr Tim Giles, Dr Inma Pérez-Gómez and **Mark Draper** take us on a journey towards the elusive perfect contact lens

Leonardo da Vinci sketched out some ideas based upon the ingenious – yet rather inelegant – concept of placing the eye in contact with a bowl of water, taking perhaps the first step in the development of contact lenses. Fast-forwarding 500 years, technology has made great strides – yet the quest for the ultimate contact lens continues.

The quest defined

In the past 20-25 years, soft contact lenses have undergone dramatic advances in the ongoing effort to fulfil the ultimate desire of lens wearers – to feel as if they are wearing no lenses at all. The challenging goal is to meet the needs and expectations of contact lens wearers and eye care professionals, while avoiding everyday comfort issues that contribute to lens discontinuation.

The motivation to do so is compelling. The benefits contact lenses provided to wearers are well documented and can be seen in any optical business. Functional benefits such as more natural vision, unimpeded vision for sport, glasses not slipping down or fogging up are complemented by powerful emotional benefits such as increased confidence for school children[1] through to enhancing natural appearance and maintaining a youthful look for presbyopes. There have also been numerous studies showing contact lens wearers contribute more to practice turnover per year and are more loyal to their optical practitioner than glasses only wearers.[2]

To that end, the ideal contact lens strives to acquire the successful merger of four key objectives: comfort, vision, health and convenience. It should provide all these features, all the time, to all contact lens wearers.

With each objective comes a host of contact lens properties that may conflict with other objectives and/or ocular needs. For instance, silicone contact lens material provides high oxygen transmissibility for corneal health, but its hydrophobicity may interfere with lens wettability – a key factor in vision and comfort. Extended wear offers convenience, but comes with a slightly higher risk. The challenge is to optimise the desired features while minimising the issues they bring.

Rex Features

Four key properties that the ideal contact lens should offer are: comfort, vision, health and convenience

The journey

The past decade has seen remarkable advances in contact lens design and polymer chemistry. With health an over-arching concern, the quest has focused mainly on contact lenses with higher Dk/t to prevent corneal hypoxia. Silicone's ability to transmit oxygen at rates much higher than earlier HEMA-based hydrogels led to the development of silicone hydrogel (SiH) contact lens materials. Table 1

provides an overview of the major currently available spherical silicone hydrogel contact lenses.

Numerous versions of SiH materials incorporated changes such as maximising Dk, increasing lens wettability in efforts to make the contact lenses more biocompatible and comfortable. Different manufacturers have approached the challenge of making SiH materials wettable, comfortable, and deposit resistant using various strategies with varying degrees of success. Some SiH lenses employ innovative plasma-treated surfaces for improved wettability while others incorporate elements such as intrinsic wetting agents and polymer changes.

Most importantly, the use of highly oxygen permeable silicone hydrogel materials has significantly reduced the number of hypoxia-related findings reported in both daily and extended wear. Hypoxia-related conditions such as microcysts, striae, bulbar and limbal hyperaemia have been virtually eliminated for contact lens wearers of SiH contact lenses.[3]

Coincident with advances in polymer chemistry have been breakthroughs in lens optical designs, bringing the goals of improved optical clarity and crisper vision within reach. Aspheric optics correct spherical aberration of the eye, front and back surface toric zones allow correction of astigmatic errors, various innovative designs now correct presbyopia. Silicone hydrogel contact lenses are now available in a wide array of designs and parameters to correct spherical, astigmatic, and presbyopic refractive errors. Advanced designs make toric soft contact lenses more comfortable and predictable to fit. Furthermore, refined manufacturing methods and technologies are now able to eliminate many of the optical distortions and defects which used to plague cast-moulded soft lenses.

These significant improvements have propelled SiH lenses into a position of prominence, showing significant growth over any other contact lens material in Europe,[4] and they are now generally considered to be the 'state-of-the-art' in soft lens technology. It is arguably only a matter of time until SiH-based materials replace HEMA based, much like in the past newer, more oxygen permeable rigid gas-permeable (RGP) technologies supplanted PMMA.

The obstacles

Despite impressive advances, certain unresolved issues present stumbling blocks for eye care professionals, researchers, scientists, manufacturers – and contact lens wearers – on the road to contact lens perfection.

Lens comfort

Fear of discomfort is the main barrier to people trying contact lenses in the first place, and lens comfort is a key issue for the estimated 125 million contact lens wearers around the globe. Recent research estimated the dropout rates to be 15.9 per cent in the US, 17 per cent in the Americas, 31 per cent in Asia, and 30.4 per cent in Europe.[5] The top reason for dropout from this study was discomfort, with 41.9 per cent to 52.9 per cent of dropouts citing discomfort as the main reason.

Factors such as lens design, lens fit, and deposit formation can impact lens comfort. However, the most common symptom experienced with contact lens wear is dryness.[6] In this regard the most important attribute of a soft contact lens is the lens surface and its interaction with the tear film. Regardless of the reason, the prevalence of comfort-related complaints and the resulting discontinuations indicate that soft contact lens wear is still not optimised.

Tear film stability

A stable tear film is necessary for successful and comfortable contact lens wear. The Dry Eye WorkShop (DEWS) implicated tear film instability as a core mechanism in the evaporative dry eye process, which includes contact lens related dry eye.[7] Tear film stability requires that the pre-corneal and pre-lens tear film be continuously supported in a way that maintains the integrity of these layers to achieve wettability, prevention of dehydration, and a smooth optical surface.

Research suggests that disturbances in the lipid layer play a predominant role in tear film instability, resulting in uneven distribution of the tear lipids, leading to evaporation of the aqueous layer, and in turn causing dryness symptoms such as ocular discomfort.[8] It appears that currently available contact lenses can destabilise the tear film by creating a thinner lipid layer, and is seen in a reduced tear breakup time and corneal staining.[9] Contact lens wear can increase tear film evaporation which contributes to complaints of dryness in contact lens wearers.[10]

Recently developed strategies have attempted to address these issues by incorporating wetting and moisturising agents. In some cases the wetting agent remains in the lens matrix to maintain lens lubricity. In others, the wetting agent is released from the contact lens into the tears. The blink-activated technology with moisturising agents gradually released during the day, have demonstrated outstanding tear film stability.[11] These innovations are welcome and have provided a degree of improved lens comfort, but thus far none of the SiH materials offer the much-needed support to the critical lipid layer of the tear film.

Surface properties

Contact lens materials must be innately designed or rendered to provide ongoing comfort and support ocular health. However, some surface properties make SiH lenses more hydrophilic which may attract lipid deposits which accumulate on the lenses over time, causing discomfort and reduced visual acuity.[12] To achieve true compatibility with the cornea and tear film will require a lens surface that mimics the cornea itself, attracting the hydrophilic aqueous layer but resisting deposition. Considering the high water content of both the cornea and the tear film layer, a uniquely designed water gradient within a contact lens from the bulk of the lens to the surface of the lens could be one solution to mediate between the technical high oxygen transmissibility of SiH and the natural composition at the point of contact. In the absence of such a panacea, lens wettability remains the more important objective, and perhaps disposable daily wear is the best resolution to this sticky problem.

Lens care solution induced corneal staining

Corneal staining has been reported due to lens care solution incompatibilities with SiH lenses.[13] A study has shown a lower incidence of solution-induced corneal staining with hydrogen peroxide systems in conjunction with SiH lenses.[13]

Lens wear and adverse events

Although the SiH materials have eliminated most hypoxia-related complications, there are other adverse events associated with wearing contact lenses, such as infectious or inflammatory adverse responses, which may still occur. These include but are not limited to microbial keratitis, epithelial microcysts, epithelial staining, infiltrates, tarsal papillary changes, conjunctival injection or iritis.

TABLE 1

Silicone hydrogel contact lenses

Manufacturer	Product name	Material name	Water per cent	Oxygen permeability (Dk)	Oxygen transmissibility (Dk/t) @-3.00D
Bausch+Lomb	PureVision	Balafilcon A	36 per cent	91	101
CIBA Vision	Air Optix Night & Day Aqua	Lotrafilcon A	24 per cent	140	175
CIBA Vision	AIR Optix Aqua	Lotrafilcon B	34 per cent	110	138
CooperVision	Avaira	Enfilcon A	46 per cent	100	125
CooperVision	Biofinity	Comfilcon A	48 per cent	128	160
Sauflon	Clariti	Filcon II 3	58 per cent	60	86
Sauflon	Clariti 1-Day	Filcon II 3	56 per cent	60	86
Vistakon	Acuvue Advance	Galyfilcon A	47 per cent	60	86
Vistakon	Acuvue Oasys	Senofilcon A	38 per cent	103	147
Vistakon	Acuvue TruEye	Narafilcon A	46 per cent	100	118
Vistakon	Acuvue TruEye (US only)	Narafilcon B	48 per cent	55	65

The quest continues

Much ground has been gained in the quest for the ultimate contact lens, yet the journey is not over. Great strides have been made in the key areas of comfort, vision, health, and convenience, yet steps must still be taken to close important gaps in unmet needs and expectations. The greatest of these unmet needs are lens comfort and reduction of adverse events.

For both new and current contact lens wearers, comfort is a key driving need and the role of tear film stability in lens comfort is well established. To quote the esteemed Brien Holden: 'Today, we have the best lenses ever – well-designed, with high oxygen transmissibility and good surfaces. What we need on top of that is a tear film that behaves as though the surface on the lens is like the eye's own surface… Our research indicates that the fundamental comfort barrier is creating a lubricious, wettable, long-lasting surface on the new generation of contact lenses.'[14]

Two other contact lens experts share similar feelings. 'Discomfort/dryness continues to remain an enigma and the holy grail of contact lenses must surely be a contact lens surface that can support a stable tear film as does the cornea and conjunctiva,' explains Desmond Fonn.[15] According to Donald Korb, 'Also, new contact lens materials that approximate the ocular surface more closely appear to be required in order to allow for optimum wettability'.[10]

For eye care professionals, improved health will continue to be a primary need in future product improvements. Unfortunately, no matter how well developed, designed, and manufactured, no contact lens will ever be able to prevent all adverse health responses. Because the contact lens is not used in a vacuum, but rather in the eye of the wearer, it is subject to person-related factors that cannot be controlled. Being human, contact lens wearers will make mistakes – both intentional and unintentional. Non-compliance will always be an issue and for eye care professionals concerned with safety and health, it seems prudent to default to modalities proven to have higher compliance, such as daily disposable and monthly lenses.[16]

Much remains to be discovered, learned and understood. As mentioned, the benefits to your patients and your practice from contact lenses are many, so advances in contact lens technology will continue – in baby steps and quantum leaps. Contact lenses are being developed with embedded circuitry, as drug delivery devices, and as corneal inlays and onlays. We are limited only by our own imaginations as we think outside the blister pack. ●

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