Available online at www.sciencedirect.com
SCIENCE DIRECT®
Contact Lens & Anterior Eye 28 (2005) 127–134
Contact Lens & Anterior Eye
www.elsevier.com/locate/clae

Changes in water content of high plus hydrogel lenses worn on an extended wear basis in a geriatric aphakic population☆

Sudi Patel [a,*], Waheeda Illahi [b], Arthur Davies [b]

[a] Vissum/Instituto Oftalmológico de Alicante, Avda de Denia s/n, Edificio Vissum, 03016 Alicante, Spain
[b] Academic Unit of Ophthalmology, Birmingham and Midland Eye Centre, Dudley Road, Birmingham B18 7QH, UK

Abstract

Purpose: To investigate the water content of hydrogel lenses of relatively high plus power hydrogel lenses after 3 months extended wear and compare values with unused lenses.
Method: Geriatric aphakic extended wear soft lens patients were fitted with one of four different brands of hydrogel lenses (A) Incanto 78 (Cantor and Nissel, UK), (B) PSL72 (Prospect lenses, UK), (C) ES70 (Ocular Sciences), (D) Proclear (Coopervision). After 3 months continuous wear the lens was removed and water content (WC) was determined at both lens surfaces using an Abbé refractometer. The water content was also measured for 40 unused lenses (+10 to +20 D, 10 lenses per brand).
Results: One hundred and thirty-two lenses were checked after 3 months extended wear. Mean (±S.D.) WC values for front (f) and back (b) surfaces of worn and unworn lenses were, respectively,

(A) Worn ($n = 45$): f 73.2(4.13) b 73.8(4.33); unworn f 80.5(0.68) b 81.1 (0.80).
(B) Worn ($n = 37$); f 70.5(4.49) b 70.9 (3.89); unworn f 72.5(0.94) b 72.3 (0.89).
(C) Worn ($n = 34$); f 68.3(3.18) b 68.4(3.63); unworn f 70.6 (0.48) b 71.1 (0.55).
(D) Worn ($n = 16$); f 63.4(3.68) b 63.3(3.19); unworn f 60.9 (1.56) b 61.5 (1.92).

There was a significant correlation between WC measured from front and back surfaces ($p < 0.01$). In worn A–C lenses, front surface WC tended to be lower than back surface WC. For lenses A and C at both surfaces the WC of worn lenses was significantly lower than unworn lenses ($p < 0.05$). For lens D, mean WC of worn lenses was significantly higher than unworn lenses ($p < 0.05$). In 80% of B lenses, surface WC of worn lenses were significantly lower than WC of unworn lenses ($p < 0.05$). There was no relationship between WC and lens power.
Conclusion: On average, A and C lenses tended to desiccate but D lenses tended to swell as did 20% of B lenses. The front surface of worn lenses measured lower water content than the back surface suggesting the front surface is drier than the back. This apparent difference in water content between the surfaces could be an artefact emanating from differential rates of surface deposition.

Keywords: Water content; Refractive index; Hydrogels; Plus lenses; Extended wear

1. Introduction

The current trend and focus on silicone based hydrogel materials is of great interest but we should not lose sight of other commonly used materials from which many soft lenses are manufactured, namely the polyvinyl pyrrolidone (PVP) based hydrogels. Hydrogel lenses can dehydrate from 1.25% [1] to 13.75% [2] during short periods of wear and the extent of dehydration depends on the exact lens material in question. Lenses of high water content ionic materials tend to dehydrate more than lenses of low water content non-ionic materials. Some manufacturers' have developed lenses that discourage on eye dehydration in order to prevent the manifestation of physiological problems associated with dehydration (e.g. Lunelle ES70 Ocular Sciences, UK and Proclear, Coopervision, UK).

☆ The authors have neither financial nor propriety interests in any of the products mentioned in this paper.

* Corresponding author at: Practitioner Services, NHSScotland, Gyle Square, 1 South Gyle Cres, Edinburgh, EH12 9EB, UK.
E-mail address: sudhir.patel@psd.csa.scot.nhs.uk (S. Patel).

1367-0484/$ – see front matter © 2005 British Contact Lens Association. Published by Elsevier Ltd. All rights reserved.
doi:10.1016/j.clae.2005.06.001

Most dehydration studies have been performed on relatively young myopes either on daily wear or that had worn lenses for a short time in controlled environment. There is precious little information on hydrogel dehydration in older patients, extended wear or plus lenses. With age the incidence of hyperopia increases [3], tear production and stability reduce [4,5]. Compared with the young the tear protein levels in the elderly are markedly different [6,7]. The drop in tear production and stability results in a tear fluid bathing the lens that is biophysically different from the tear fluid bathing the lens in a younger eye. A good lipid layer over the precorneal tear film is essential to maintain tear stability and reduces the rate of ocular surface evaporation [8,9]. Tear evaporation increases during lens wear [10] and it is generally believed, the scant lipid layer over the contact lens is a prime reason for this increased evaporation.

During the period between blinks there are demands on ocular surface fluid from both the anterior ocular structures and the hydrogel lens. If the hydrogel has stronger hydrophilic properties compared with the ocular structures in the older eye, the lens could dehydrate less than expected. The lens may even swell. Alternatively, if the tear production rate is reduced in the older eye the lens is competing with local tissue and ambient air to hold on to the limited amount of water present. On balance, this may cause the lens to dehydrate more than in the younger eye. Furthermore, the tear film and lacrimal lake is compromised during sleep [11] and this may be an additional factor influencing the water content of the lens during waking hours. Along the antero-posterior direction the percentage water content of the cornea gradually increases [12–15]. This may result from the changing biophysical nature of the stromal collagen along this antero-posterior direction coupled with a net out flow of water from the stroma and into the precorneal tear layer. During wear if there is a similar out flux of water from the hydrogel lens anterior surface then, the lens front surface should be less hydrated than the lens posterior surface. A dynamic equilibrium may ensue whereby the anterior surface has a hydration level that may be lower than the hydration level at the posterior surface during wear.

In most studies on lens dehydration, water content has been estimated by measuring lens refractive index using the Abbé refractometer [1,16–21]. The relationship between lens refractive index and water content can be predicted using the Gladstone–Dale Law [22] that predicts, a rise in refractive index when the water content reduces.

In essence, lens surface refractive index is measured and this value is used to infer total lens water content. However, by its own nature, Abbé refractometry is a lens surface not an intra-lens measurement. If there is a significant difference in water content in vivo between the front and back surfaces of a hydrogel then, Abbé refractometry should detect it. The aim of this study was to measure the refractive index and infer the water content of hydrogel lenses:

(1) of plus power;
(2) worn by a predominately older population on an extended wear basis;
(3) at both front and back surfaces.

2. Methods

2.1. Lens' refractive index and water content

The lens water content was determined using a hand held portable Abbé refractometer (Sugar refractometer, Bellingham & Stanley, UK). This model is normally used for checking the sugar content of foodstuffs. The refractometer scale had been precalibrated using freshly prepared sucrose solutions of various concentrations and the refractive index-lens water content relationship had been determined using several ($n = 35$) unused hydrogel lenses (nominal water content 37–79% at room temperature 20–22 °C). The test-retest reliability of the refractometer was checked by measuring the refractive index hence water content of one lens (ES70, Ocular Sciences UK) on 10 separate occasions and noting the standard deviation about the mean.

After opening the refractometer prism housing, the front surface of the lens under test was placed directly on to the measuring prism. The prism housing was closed and the scale reading was read off after directing the refractometer towards a light source. The prism housing was opened, the lens was turned over and the measurement was repeated for the lens' back surface. The front surface refractive index/water content measurement always preceded back surface measurement.

2.2. Subjects

All subjects were, elderly aphakes adapted to extended wear of high water content hydrogel lenses, returning for a routine 3 month check up and lens replacement. None of the subjects exhibited signs to justify the cessation of extended lens wear. All subjects were informed as to the nature of this study and all participants had given signed consent. When attending the hospital based contact lens clinic, the patient's existing lens/es was removed and replaced with one of four different types of hydrogel lenses. Details of lens' power, base curve and diameter were pre-selected to ensure a suitable fit. A full aftercare was done, on condition there were no contraindications, the replacement lens was placed on the cornea and the patient was reviewed 3 months later. At the follow up, one member of the investigating team removed the lens from the eye and using the refractometer the water content was measured at both lens surfaces. The lens was discarded and replaced using another lens type and the patient was reviewed again 3 months later. The water content was not measured before placing the lens on the eye. Heavily deposited lenses were not included in the study because the