Contact Lens & Anterior Eye 38 (2015) 2–14

Contents lists available at ScienceDirect

Contact Lens & Anterior Eye

journal homepage: www.elsevier.com/locate/clae

# Power profiles of single vision and multifocal soft contact lenses

Sandra Wagner[b], Fabian Conrad[a], Ravi C. Bakaraju[a], Cathleen Fedtke[a], Klaus Ehrmann[a,c,*], Brien A. Holden[a,c]

[a] Brien Holden Vision Institute, Sydney, Australia
[b] Aalen University, Germany
[c] School of Optometry and Vision Science, University of New South Wales, Sydney, Australia

ARTICLE INFO

*Article history:*
Received 4 April 2014
Received in revised form 11 July 2014
Accepted 21 July 2014

*Keywords:*
Power profiles
Soft contact lenses
Multifocal contact lenses
Spherical aberration

ABSTRACT

*Purpose:* The purpose of this study was to investigate the optical zone power profile of the most commonly prescribed soft contact lenses to assess their potential impact on peripheral refractive error and hence myopia progression.
*Methods:* The optical power profiles of six single vision and ten multifocal contact lenses of five manufacturers in the powers −1.00 D, −3.00 D, and −6.00 D were measured using the SHSOphthalmic (Optocraft GmbH, Erlangen, Germany). Instrument repeatability was also investigated.
*Results:* Instrument repeatability was dependent on the distance from the optical centre, manifesting unreliable data for the central 1 mm of the optic zone. Single vision contact lens measurements of −6.00 D lenses revealed omafilcon A having the most negative spherical aberration, lotrafilcon A having the least. Somofilcon A had the highest minus power and lotrafilcon A the biggest deviation in positive direction, relative to their respective labelled powers.

Negative spherical aberration occurred for almost all of the multifocal contact lenses, including the centre-distance designs etafilcon A bifocal and omafilcon A multifocal. Lotrafilcon B and balafilcon A seem to rely predominantly on the spherical aberration component to provide multifocality.
*Conclusions:* Power profiles of single vision soft contact lenses varied greatly, many having a negative spherical aberration profile that would exacerbate myopia. Some lens types and powers are affected by large intra-batch variability or power offsets of more than 0.25 dioptres. Evaluation of power profiles of multifocal lenses was derived that provides helpful information for prescribing lenses for presbyopes and progressing myopes.


## 1. Introduction

As contact lenses have become more complex in their optical designs – especially with respect to multifocal lens designs – new methods had been developed to accurately measure the distribution of power within such lenses. The present study aimed to determine the power profiles of a diversity of commercially available single vision and multifocal soft contact lenses using the wavefront sensor SHSOphthalmic (Optocraft GmbH, Erlangen, Germany).

Over the last couple of years, peripheral refraction has received increasing attention in myopia research, based on the theory that relative peripheral hyperopic defocus can promote the onset or progression of myopia [1–3]. Mutti et al., amongst others [4–6], also demonstrated that there is an association between myopia in children and relative peripheral hyperopia [7].

Contact lenses with negative spherical aberration can influence the peripheral refraction of the eye and increase the relative peripheral hyperopia in myopic eyes, thereby potentially promoting the progression of myopia. On the other hand, specific multifocal contact lens designs are able to reduce the progression, as described recently by several research groups, primarily by moving the peripheral image forward as suggested by Smith et al. [8–14].

A variety of wavefront sensing instruments for measuring refractive power and power distribution of contact lenses have recently become available, some of which have been evaluated in previous studies.

Joannes et al. assessed the phase shifting schlieren method incorporated in the Nimo TR1504 (LambdaX, Nivelles, Belgium). On the basis of a quantitative deflectometry technique, light beam

* Corresponding author at: Brien Holden Vision Institute, Level 3, North Wing, RMB, Gate 14, Barker Street, University of New South Wales, Sydney, NSW 2052, Australia. Tel.: +61 2 9385 7495; fax: +61 293857401.
*E-mail address:* k.ehrmann@brienholdenvision.org (K. Ehrmann).

http://dx.doi.org/10.1016/j.clae.2014.07.008
1367-0484/

deviations were measured in order to receive power data of soft and rigid contact lenses over a field of view of 15 mm × 15 mm and a spatial resolution of 36 μm. Reproducibility for sphere power was found to be good, with a standard deviation of 0.048 D for spherical soft lenses [15]. The specifications and features of this instrument are comparable to those of the SHSOphthalmic [16,17].

Ehrmann and Falk developed an optical system for power mapping of intraocular and contact lenses using a paraxial laser scan. Lateral resolution was found to be approximately 20 μm and power accuracy in the order of milli-diopters. Independent measurements revealed good instrument repeatability with standard deviations of less than 0.1 D [18].

Kollbaum et al. evaluated accuracy and repeatability of ClearWave Contact Lens Precision Aberrometer (AMO Wavefront Sciences, Albuquerque, NM), measuring aberrations of plano-convex, plano-concave calibration lenses, and spectacle lenses, as well as of common soft and rigid contact lenses. Both ClearWave and SHSOphthalmic are based on the Hartmann–Shack technique – while the ClearWave contains a 101 × 101 lenslet array, the SHSOphthalmic applied in this study holds 116 × 116 microlenses. The lateral sampling resolution of the ClearWave is 0.104 mm, a little lower than the 0.069 mm of the SHSOphthalmic [16,17,19]. The results of the study by Kollbaum et al. demonstrated good repeatability for the ClearWave instrument, having errors of <1%. As with all the other instruments, soft contact lenses are measured in a saline filled wet cell, which prevents dehydration during the measurement, but requires a conversion to in-air equivalent power [20].

The Visionix VC 2001 (Nana Tech Enterprise, Singapore) is another Hartmann–Shack power mapping instrument that enables measurements with repeatability of 0.03 D, taken in five annuli of 1 mm width, respectively [21,22]. In comparison, the SHSOphthalmic enables evaluation with an individual choice of up to ten annular zones [16,17].

Very recently, Plainis et al. [23] evaluated the Phase Focus Lens Profiler (Phase Focus Ltd., Sheffield, UK) and compiled power profiles of four multifocal soft contact lens types. The instrument measures thickness maps of the complete contact lens, which can then be converted into Dk/t or power maps. The power maps can be derived with a mean spherical power repeatability of 0.02 D. Thickness measurements are obtained by scanning a laser beam over the sample and combining the captured diffraction patterns produced by the scattered light to reconstruct the thickness map [23,24].

The advantages of wavefront sensing instruments in providing a continuous profile of the lens power were noted by Vogt and Kingston, who compared a traditional projection vertexometer (Nikon PL-2) to a Hartmann–Shack wavefront aberrometer (Optocraft SHSInspect TL) by measuring the power zones of two different types of multifocal soft contact lenses [25].

The reported power profiles in the current literature were measured using several different instruments and the selection of lens types and powers was generally limited. The purpose of this study was to assemble a catalogue of power profiles of various commercially available spherical single vision and multifocal soft contact lenses, using the same instrument and procedure for direct comparison. ISO 18369-3 makes reference to Hartmann–Shack type instruments for spherical and cylindrical power measurements, but does not specify any accuracy requirements for the measurement of power profiles or multifocal contact lenses. Instrument and method repeatability was therefore also assessed. By taking into consideration published available evidence regarding how certain power profiles can affect visual performance and acceptance, for both the presbyopic and the young progressing myopic patient, the power profile information in this catalogue can aid practitioners in prescribing the most appropriate contact lens.

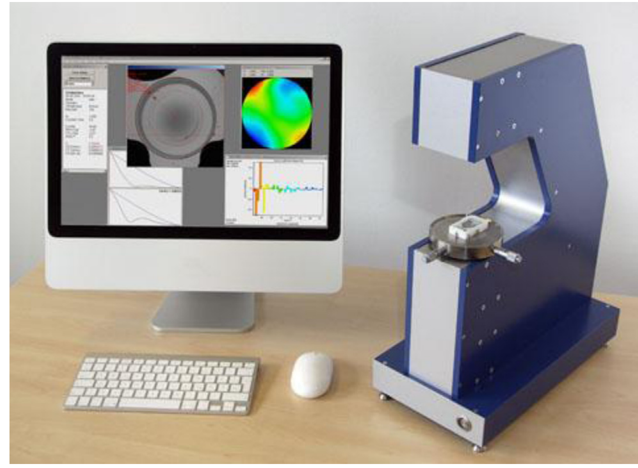

**Fig. 1.** Wavefront sensing instrument SHSOphthalmic by Optocraft [38].

## 2. Methods

### 2.1. Instruments

#### 2.1.1. SHSOphthalmic

The SHSOphthalmic (Fig. 1) is a universal test system for ophthalmic lenses, including rigid and soft contact lenses as well as intra-ocular lenses. It generates power maps and power profiles, from which lens power (sphere, cylinder, axis, and prism) is calculated. Measurements are based on the Hartmann–Shack principle: The wavefront strikes a 116 × 116 micro-lens array while a CCD-Chip in the focal plane detects the lateral position of each focus [26]. Comparing the lateral displacements of the rays against their reference positions, the wavefront can be reconstructed via numerical integration [16,17,27] (Fig. 2).

#### 2.1.2. CLOQA (contact lens optical quality analyser)

This custom-built optical system (Brien Holden Vision Institute, Sydney, Australia) allows the rapid visual assessment of the design and quality of a contact lens. The instrument visualises the power distribution within the optical zone as well as revealing the design of the peripheral zones of contact lenses. It can also be used to detect optical defects and physical damage.

The CLOQA is based on the Foucault knife-edge test: It consists of a slit light source, the standard lens and the objective lens, that focus the wavefront in the plane of the knife-edge [28]. A CCD video camera captures the colour coded wavefront image of the contact lens (Fig. 3).

The field of view circumscribes 15 mm, so that even the largest available soft contact lens can be assessed completely. Soft contact lenses are placed inside a wet cell filled with standard phosphate buffered saline (PBS, ISO 10344).

In the present study, the CLOQA has been used to visualise fine defects on the lens surface.

### 2.2. Contact lenses

Sixteen types of single vision and multifocal soft contact lenses from five manufacturers were tested (Table 1).

The refractive power of each contact lens was measured by the SHSOphthalmic within an optical zone of 8 mm diameter, using the auto edge detection mode. For each of the different contact lens types, five samples of powers −1.00 D, −3.00 D, and −6.00 D were measured once. Altogether, 240 contact lenses were investigated.