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In vitro power profiles of multifocal simultaneous vision contact lenses

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ABSTRACT

Purpose: To evaluate the power profile of multifocal contact lenses (CLs) using a new technology based on quantitative deflectometry.
Methods: The Nimo TR1504 was used to analyze the power distribution of multifocal CLs. The CLs under study were: Air Optix Aqua Multifocal Low, Medium and High Addition and Focus Progressives. Three lenses of each model were considered.
Results: All multifocal CLs showed a power profile characterized by a change toward more positive power values when aperture sizes become smaller. The near refractive addition of the lenses under study was +2.61 D, +1.44 D, +1.30 D and +0.30 D for the Focus Progressives, the Air Optix Aqua Multifocal High, Medium Add and Low Add, respectively. The refractive power of the Focus Progressives did not reach the value of the nominal distance power until a radial distance of 0.9 mm from the center of the lens. For the Air Optix Aqua Multifocal Low Add the distance nominal power was reached at a radial distance of 1.5 mm from the center of the lens, whereas this occurred at a distance of 1.8 mm for the Air Optix Aqua Multifocal Medium and High Add.
Conclusion: The relation between the pupil diameter of the patients and the power profile of these CLs has a crucial implication on the final distance correction and near addition that these lenses provide to patients. Practitioners should know the power profile of these CLs and measure the pupil diameter of each patient in different situations in order to carry out a customized fitting.

1. Introduction

Population aging was a key demographic issue during the 20th century, and it will most likely become the distinctive feature during the 21st century [1]. One of the main visual consequences of population aging is presbyopia. This condition is generally first reported clinically between 40 and 45 years of age, with its peak onset between 42 and 44 years [2,3], and from the age of 52 years the prevalence of presbyopia is considered to be essentially 100%. Taking into account these data and the expectation that the population aged >60 years will reach 22% of the whole world population in 2050 [1], it could be considered that presbyopia correction is and will be one of the most important areas of contact lens practice. However, currently there are low levels of presbyopia-correction with contact lenses for patients aged >45 years [4]. When presbyopia is corrected with contact lenses, multifocal contact lenses are fitted 3.6 times more frequently than monovision lenses [4].

Most designs of multifocal contact lens use the concept of simultaneous focus, that is, the contact lens has multiple powers positioned within pupil at the same time. However, practitioners normally have no information about the power profile of these lenses. Manufactures only provide a few parameters such a basic description of the design (near or distance center), the refractive power for distance vision and the nominal addition power. A knowledge of complete power profiles would give practitioners a better understanding of the behavior of these lenses and it could improve the nomogram fitting for each individual patient. Consequently, the rates of prescribing of multifocal contact lens could be increased for presbyopic population.

In this context, the aim of the present study was to provide the power profile of some recent designs of multifocal contact lenses using a new technology based on a quantitative deflectometry technique. Additionally, we discuss how the distance and near correction provided by these lenses varies with the pupil diameter.

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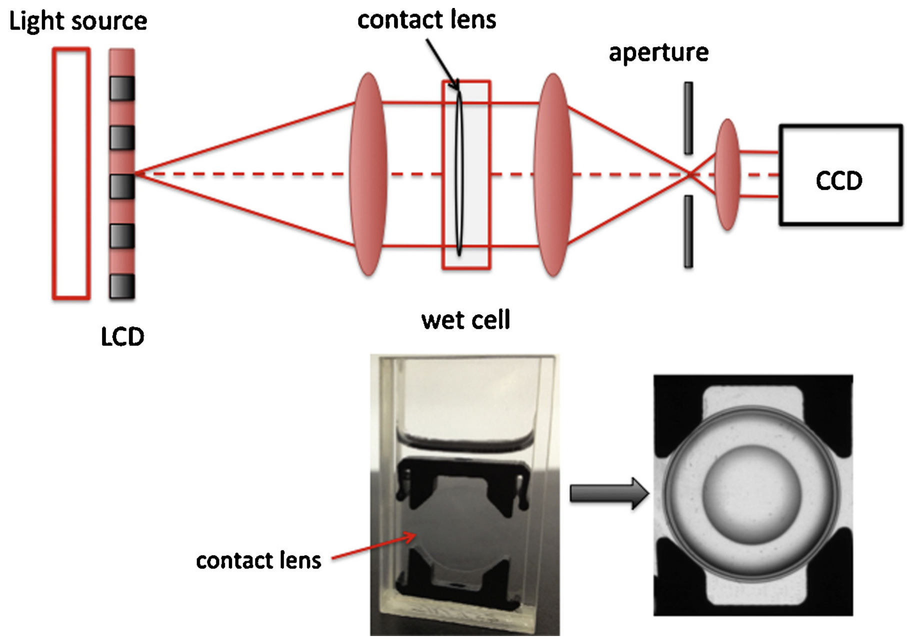

Fig. 1. Schematic layout of the NIMO TR1504. This instrument consists of a cold cathode tube backlight sources that emits green light at 546 nm, incorporating an additional diffuser and a ±10 nm bandwidth filter to the source to homogenize and limit the spectral width of the light beam. A liquid crystal display (LDC) placed at the focal length of the lens L1 that is the lens responsible for collimating the light beam. Two lenses, L2 and L3, which form an image on camera through a telecentric arrangement and a CCD camera with a native pixel resolution of 1396 × 1340 pixels corresponding to a spacing of 69 pixel/mm or 1761 pixel/in. The high resolution of the camera is directly related to the high instrument resolution (36 μm).

2. Methods

2.1. Multifocal CLs employed in the study

According to the manufacturer, the Air Optix Aqua Multifocal (Alcon Laboratories, Fort Worth, US) is a simultaneous-vision contact lens having an aspheric (both front and back surfaces are aspheric; base curve of 8.6 mm) center-near design, with a total lens diameter of 14.2 mm. For each lens, the near and intermediate powers are primarily concentrated in the central portion of the optic zone while the distance power is contained in the surrounding portion. The lens is manufactured from lotrafilcon B, which has a 33% water content. This type of lens is available from −10.00 D to +4.00 D in steps of 0.25 D and at the same time, it presents 3 different add powers: "low addition" (add≤1.00 D), "medium addition" (add between 1.25 and 2.00 D) and "high addition" (add > 2.00 D).

The other multifocal CL under study was the Focus Progressives (Alcon Laboratories, Fort Worth, US). This lens is described as a simultaneous multifocal contact lens with a base curve of 8.6 mm and a total lens diameter of 14.0 mm. The lens has an aspheric front surface capable of providing a reading addition of up to +3.00 D. The lens is manufactured from vifilcon A that has a water content of 55%. The lens has a continuous power gradient, beginning with the near zone at the lens center.

2.2. Instrument

The Nimo TR1504 (LAMBDA-X, Nivelles, Belgium) was used to map the power distribution within the optic zone of the contact lenses. This instrument uses a new technology based on a quantitative deflectometry technique described as phase-shifting schlieren that has been applied to measure contact lenses [5–8]. Fig. 1 shows a schematic layout of the NIMO TR1504. A previous study [8] has reported the accuracy and repeatability of this technology applied to soft contact lens immersed in saline solution. The results of this previous study demonstrated that the schlieren method is more precise than any current ISO-referenced method. Moreover, the authors of this study found that a single measurement is enough to determine the sphere power to current ISO tolerance limits with 95% confidence and that only two measurements are required to determine the cylinder power to the same confidence level. The technical characteristics of the Nimo TR1504 and the way in which it measures the power of a contact lens have previously been described in the scientific literature [5–8]: a major advantage is its spatial resolutions (about 40 μm) [8].

The Nimo device allows variation in the diameter of aperture used to perform the measurements. In this way, a detailed evaluation of refractive power distribution within the optic zone of contact lenses can be performed without removing the contact lens from the support.

Because soft contact lenses are measured in a suitable wet cell to maintain the surface profiles and hydration during the measurement, and lens dimension are specified in air, the Nimo TR1504 software converts the effective power of soft contact lenses measured in saline solution to back vertex power in air. First, the lens front surface ($r_{\alpha 0}$) is calculated from the effective power (Ø) measured by the schlieren instrument in wet state using the following equation:

$$t_{a0} = \frac{(n-n')nr_0 + t(n-n')^2}{\phi r_0 n + (n-n')n}$$

Then, the back vertex power in air ($F'v$) is calculated from:

$$F'v = \frac{n(n-1)}{nr_{a0} - (n-1)t} - \frac{n-1}{r_0}$$

where n is the refractive index of contact lens material; n' is the refractive index of saline solution in which the lens is immersed; r_0 is the contact lens back curvature; t is the central thickness of contact lens