



Resultant vertical prism in toric soft contact lenses



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ABSTRACT

Purpose: Rotational stability of toric soft contact lenses (TSCLs) is achieved using a range of designs. Designs utilising prism or peripheral ballast may result in residual prism in the optic zone. This study quantifies the vertical prism in the central 6 mm present in TSCLs with various stabilisation methods.

Method: Vertical prism was computed using published refractive index and vertical thickness changes in the central optic zone on a full lens thickness map. Thickness maps were measured using scanning transmission microscopy. Designs tested were reusable, silicone hydrogel and hydrogel TSCLs: SofLens[®] Toric, PureVision[®] 2 for Astigmatism, PureVision[®] Toric, Biofinity[®] Toric, Avaira[®] Toric, clariti[®] toric, AIR OPTIX[®] for ASTIGMATISM and ACUVUE OASYS[®] for ASTIGMATISM; with eight parameter combinations for each lens (−6.00 DS to +3.00 DS, −1.25 DC, 90° and 180° axes).

Results: All TSCL designs evaluated had vertical prism in the optic zone except one which had virtually none (0.01 Δ). Mean prism ranged from 0.52 Δ to 1.15 Δ, with three designs having prism that varied with sphere power. Vertical prism in ACUVUE OASYS[®] for ASTIGMATISM was significantly lower than all other TSCLs tested.

Conclusions: TSCL designs utilising prism-ballast and peri-ballast for stabilisation have vertical prism in the central optic zone. In monocular astigmats fitted with a TSCL or those wearing a mix of toric designs, vertical prism imbalance could create or exacerbate disturbances in binocular vision function. Practitioners should be aware of this potential effect when selecting which TSCL designs to prescribe, particularly for monocular astigmats with pre-existing binocular vision anomalies, and when managing complaints of asthenopia in monocular astigmats.

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1. Introduction

Toric soft contact lenses require rotational stability for consistent visual performance. Various methods are used to stabilise rotation, including prism-ballast, peri-ballast and thin-zone designs (also known as double slab-off or dynamic stabilisation) [1].

Prism-ballast designs utilise prism to orientate and stabilise the lens, although early designs have since been modified with the aim of improving comfort, and thinner lens profiles for an improved oxygen performance [2]. Peri-ballast designs are similar in concept to prism-ballast; the superior portion of the lens is

thinned to produce a prism-like rotational stabilisation effect [1]. An advantage to these designs, compared to standard prism-ballasted lenses, is said to be that there is essentially no prism in the optical portion of the lens [1].

Of the thin-zone designs, Accelerated Stabilisation Design (ASD) lenses use the thickness of the contact lens and both the upper and lower eyelid movements to achieve rotational stability, and have been shown to have advantages over other toric designs under a range of viewing conditions [3–5]. These lenses have four zones of stability, minimal thickness under both lids, and are designed to have no residual prism in the optic zone [6].

Prism located within the optic zone of a toric soft lens may induce vertical binocular imbalance if the patient is prescribed the prism design in only one eye, in particular in those with existing vertical phoria-related problems [7]. Greater than 0.5 Δ vertical prism disparity could lead to binocular disturbance, symptoms such as asthenopia, nausea, visual discomfort and motion sickness, and decrease stereopsis in some patients [8–10]. However, few

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Table 1
Reusable toric soft lenses tested.

Product	Material	Manufacturer	Design
ACUVUE OASYS® for ASTIGMATISM	senofilcon A	Johnson & Johnson Vision Care	Accelerated Stabilisation Design (ASD)
AIR OPTIX® for ASTIGMATISM	lotrafilcon B	Alcon	Modified peri-ballast
Biofinity® Toric	comfilcon A	CooperVision	Peri-ballast
Avaira® Toric ^a	enfilcon A	CooperVision	Peri-ballast
clariti® toric	somofilcon A	Sauflon	Prism-ballast
PureVision®2 for Astigmatism	balafilcon A	Bausch + Lomb	Modified peri-ballast
PureVision® Toric	balafilcon A	Bausch + Lomb	Prism-ballast
SofLens®Toric	alphafilcon A	Bausch + Lomb	Prism-ballast

^a +3.00 DS not available so six parameter combinations were tested covering –6.00 DS to –1.00 DS.

clinical studies have investigated the on-eye effects of differences in vertical prism seen with contact lenses.

The purpose of this study was to quantify the vertical prism in the central 6 mm present in toric soft contact lenses with various stabilisation methods.

2. Methods

Eight reusable toric soft contact lenses manufactured from silicone hydrogel and hydrogel materials were tested, with eight parameter combinations per lens type covering sphere powers from –6.00 DS to +3.00 DS, cylinder power of –1.25DC and with 90° and 180° axes. The cylinder power chosen is the most commonly prescribed toric soft contact lens parameter, and demonstrates thickness changes across the lens. The lens types were selected to represent a range of stabilisation methods, designs and manufacturers (Table 1).

Open-label (unmasked), randomised testing of lenses was conducted by the independent company Phase Focus Limited (Sheffield, UK) using a scanning transmission microscopy method called ptychography (proprietary imaging system of hydrated soft lenses), which yields transmitted phase across the entire lens [11]. A standard sample was tested before and after each test sample to ensure accuracy of readings. Thickness maps were generated by determining the phase shift that occurs as light travels through the lens at over 3 million positions. These data, when combined with the published refractive index (provided to Phase Focus for each lens from the lens' FDA 510k details) and measured centre thickness of the contact lens, were then used to compute a thickness map of the entire lens. The maps display the thickness across the lens with a colour-specified range from 0 to 400 μm .

Vertical prism of the toric contact lenses was computed in the central 6 mm optic zone on the full lens thickness maps;

measurements over the lens surface used more than 650,000 thickness points in the 6 mm zone. An area of 6 mm was chosen as it represented an average pupil diameter in a younger patient (mean pupil diameter shown to range from 5.5 mm to 7.5 mm for those aged 1 month to 19 years [12]) and avoided any potential edge effects if some of the toric soft lens designs blended the optic zone. Calculated prism did not change with optic zone size; if changes were observed, it would indicate the presence of additional aberrations in the lens that change the line of sight.

The software used to calculate the amount of prism was developed by Johnson & Johnson Vision Care, Inc. using IDL 6.3 software (Research Systems Incorporated). The software analysed thickness profiles of lenses oriented in nominal rotational position on-eye (scribe marks vertical or horizontal, depending on design). Thickness maps were read in as an array, with X horizontal and Y vertical. A 'mask' was created for the central 6 mm to allow the software only to use data points meeting the central 6 mm criteria for analysis. The first order was fit in X and Y to all points in the masked region, with the sample formula being thickness = $m \cdot X + n \cdot Y + C$, where m was the horizontal thickness change, n the vertical thickness change and C the intercept. The vertical thickness change was converted to the angle between front and back contact lens surfaces (arctan of the slope), and vertical prism was computed using prism angle and the refractive index data (code used for formula; Snell's law refraction caused by prism angle).

Using a least-squares fitting technique on the central 6 mm thickness profile, the prism angle was determined from the average slope along the vertical meridian and was used with the published refractive index value to compute the vertical optical prism for each lens (see Fig. 1 for example). The colour-scale representations of the thickness map are displayed from 0 to 400 μm .

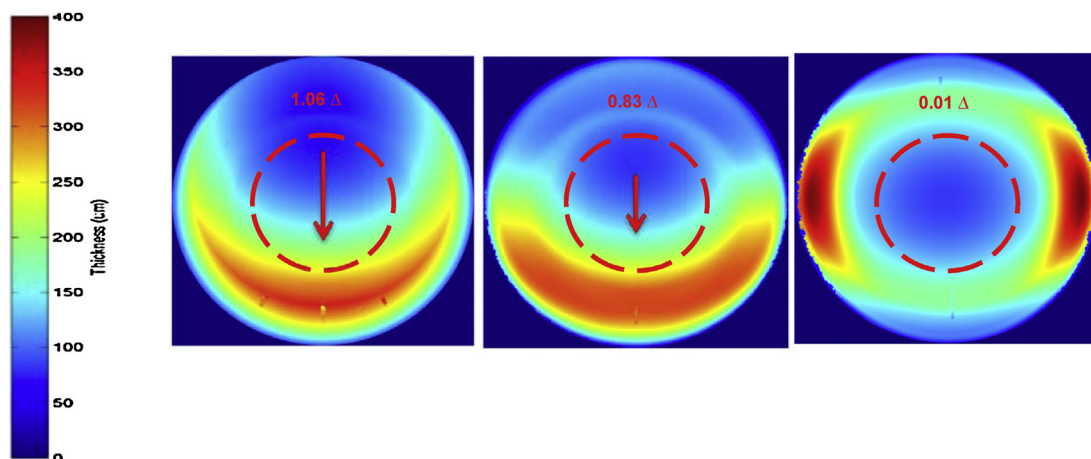


Fig. 1. Example of thickness profiles; central 6 mm region represented by red dotted circle. Lenses with differing levels of vertical prism (0 to 400 μm) shown to demonstrate thickness change.

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