

# measuring non-spherical optical surfaces

Craig A Woods PhD

Clinical Vision Research Australia, Victorian College of Optometry,  
University of Melbourne, Australia

## Introduction

The use of novel designs to generate varifocal optics in contact lenses is increasing. Designs incorporate aspheric shapes, of known  $p$ -values on the front and back surface of rigid contact lenses<sup>1</sup>. Frequently the back optical zone radius quoted by the manufacture is nominal, making verification of these lenses difficult. Can a videokeratoscope or an optical microspherometer (radiuscope) verify these complex surfaces?

## Methods

This study assessed whether practice equipment can verify complex surfaces of contact lenses. 54 concave surfaces (Figure 1) of known curvatures (7.30mm to 8.10mm, in 0.1 steps) and known  $p$ -values (1.0 to 0.0, in 0.1 steps) were produced. Two methods of measure were investigated:

### method a (sag)

By measuring the vertex radius, sagittal height and chord diameter of the curve, the degree of asphericity could be calculated (Figure 1):<sup>2</sup>

$$p = \frac{2rs - (\frac{D^2}{4})}{s^2}$$

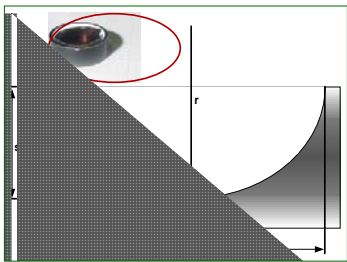


Figure 1: Schematic of lens button (actual semi-finished button, insert)

### method b (vk)

By measuring the lens surface with a videokeratoscope, the vertex radius and degree of asphericity can be determined (Figures 2&3).<sup>3</sup>

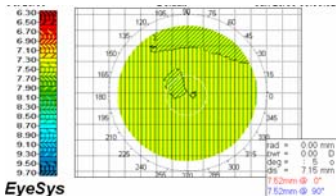


Figure 2: VK plot of a spherical concave surface

**control measure**  
Both methods were compared to the results from surface profilometry, *Form TalySurf*.

## Results

Form TalySurf-	Bias		Limits of agreement
	method A/B (mean)	agreement	
<b>vertex radius</b>			
Method A (sag)	0.008mm	±0.01mm	±0.072mm
Method B (VK)	-0.017mm	±0.012mm	±0.096mm
<b>p-value</b>			
Method A (sag)	0.134	±0.078	±0.574
Method B (VK)	-0.052	±0.018	±0.136

Table 1: Discrepancy results for Methods A and B compared to the Control method

	Method A (Sag)	Method B (VK)	Form TalySurf
Mean	7.69mm	7.71mm	7.69mm
Standard Deviation	±0.27mm	±0.27mm	±0.26mm
Standard Error	±0.04mm	±0.04mm	±0.04mm
Min	7.26mm	7.28mm	7.30mm
Max	8.17mm	8.14mm	8.10mm

Table 2: Results of the measure of apical radius for all methods of measure

	Method A (Sag)	Method B (VK)	Form TalySurf
Mean	0.37	0.55	0.50
Standard Deviation	±0.31	±0.34	±0.30
Standard Error	±0.04	±0.05	±0.05
Min	-0.35	-0.07	0.0
Max	0.90	1.15	1.00

Table 3: Results of the measure of the p-value for all methods of measure

Discrepancy analysis was used to compare the results of the different methods of measure (Figures 4-7).<sup>4</sup>

Optical microspherometry verified the vertex radius to a high degree of accuracy without bias, but, was poor verifying the  $p$ -value with bias (Table 1).

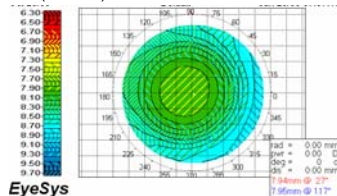


Figure 3: VK plot of an aspherical concave surface

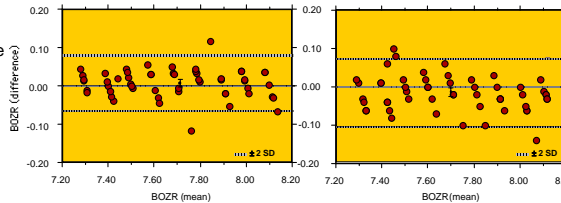


Figure 4: The difference (Method A - Control method) against mean for vertex radius

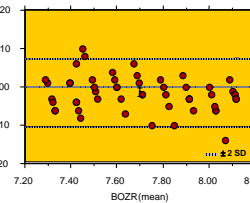


Figure 5: The difference (Method B - Control method) against mean for vertex radius

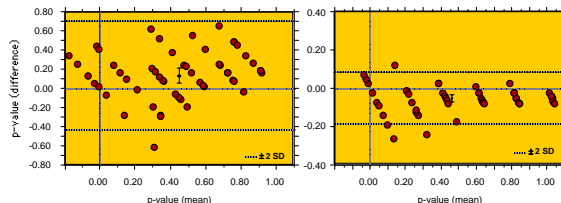


Figure 6: The difference (Method A - Control method) against mean for p-value

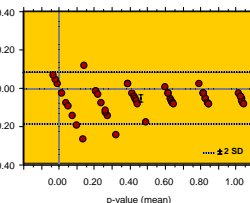


Figure 7: The difference (Method B - Control method) against mean for p-value

The accuracy for the vertex radius with the videokeratoscope, was high but with bias. The  $p$ -values were described with accuracy also with bias (Table 1).

No statistical difference between the methods of measure was found for the apical radius (Table 2).

Measurement of the  $p$ -values with the optical microspherometer were statistically significantly different from the control measurement ( $p=0.0379$ ) and the videokeratoscope ( $p=0.0042$ ) (Table 3).

## Discussion

The purpose of this study was to determine if practice equipment could assess aspherical optical concave surfaces in terms of vertex radius and  $p$ -value.

### method a (sag)

A tolerance of  $\pm 0.0098$ mm was needed to measure the sagittal height. The chord measurement required a mag. of x20; a CCTV system (low vision) was used. The accuracy needed to measure the vertex radius ( $\pm 0.0625$ mm) was possible using an optical microspherometer.

### method b (vk)

EyeSys software for windows was used to measure the concave surface. The tabular data was exported and the  $p$ -value was calculated.<sup>3</sup>

## the vertex radius

The optical microspherometer is the accepted method to measure the vertex radius for rigid contact lenses in practice. This study confirmed that confidence. The accuracy was also high for non-spherical surfaces, regardless of the degree of eccentricity and without bias, assuming clinical significance of 0.1mm and not 0.05mm.

The videokeratoscope demonstrated a high degree of agreement for the vertex radius but with bias (over estimating the vertex radius by 0.017mm). This level of agreement was attained when the videokeratoscope was calibrated for concave surfaces and able to be manually focused.

Both methods were shown not to be statistically different from the control, Form TalySurf.

## the p-value

Method A (sag) compared poorly to Form TalySurf ( $\pm 0.574$ ) and showed bias (overstating the asphericity by 0.134).

Both the poor limit of agreement and the bias demonstrates that the measures did not provide the required accuracy or precision.

Method B (VK) was able to deliver the required degree of accuracy (0.136) but with bias (under estimating the asphericity by -0.052).

For Method B (VK), the  $p$ -value was not statistically significantly different from Form TalySurf. Method A (sag) was statistically significantly different from the other two methods.

## Conclusion

To determine the degree of asphericity of a concave optical surface to an acceptable degree of accuracy a videokeratoscope can be used in preference to an optical microspherometer. Both instruments demonstrated a high degree of accuracy for the vertex radius.

## References

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## Address for correspondence

Craig Woods, CVRA, Victorian College of Optometry, University of Melbourne, Cnr Keppel and Cardigan Sts, Carlton 3053, Victoria, Australia.  
c.woods@optometry.unimelb.edu.au

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