POWER PROFILES OF MULTIFOCAL CONTACT LENSES AND THEIR INTERPRETATION

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1. INTRODUCTION

Many contact lens (CL) manufacturers produce simultaneous-image (vision) lenses in which the power varies either smoothly or discontinuously with zonal radius. Although manufacturers describe these lenses as being centre-near or centre-distance designs, and may assign them distance-correcting and add powers, the power profiles of the lenses are not reported in detail, making it difficult to properly assess the likely merits and disadvantages of any particular product.

We present here in-vitro measurements made on some recent designs of concentric presbyopic CLs and discuss how their power profiles might be approximated in terms of near additions.

2. METHODS: Instrument and Contact Lenses

The fully-hydrated lenses were measured with a Phase Focus Lens Profiler (Phase Focus Ltd, Sheffield, UK) in a wet cell*. This instrument uses the technique of ptychographic imaging[1] in which a series of diffraction patterns is recorded from neighboring points on the lens and is used to reconstruct the lens thickness profile, and hence its power profile.[2] A selection of soft, multifocal contact lenses from four manufacturers (with plano labelled power for distance) was measured:

1. Air Optix (AO) AQUA Multifocal (Alcon) – low, medium and high add lenses (centre-near aspheric / bi-aspheric designs)
2. Purevision (PV) multifocal (Bausch & Lomb) – low and high add lenses (centre-near aspheric / bi-aspheric designs)
3. Acuvue OASYS for Presbyopia (Vistakon) – low, medium and high add lenses (concentric aspheric distance/near zones)
4. Biofinity multifocal (Cooper Vision) of the "D" design – +1.50, +2.00 and +2.50D add lenses (centre-distance designs).

4. RESULTS: Power profiles (aspheric / bi-aspheric multifocals)

Figure 2 presents sagittal power profile data, obtained by averaging the power around each annular zone of the lenses. Power profile data revealed that the "low" add PV and AO lenses exhibit parabolic profiles, corresponding to negative spherical aberration, and can therefore be fitted[3] by the following equation: $\mathbf{P_y = P_0 + by^2}$ **[1] ,**

where y is the radial distance from the lens centre (in mm), P_0 is the paraxial power (at y=0), P_y is the power at radius y and b is a constant which characterizes the power changes as a function of y.

Since the power varies with y^2, the power at radius $y_{max}/\sqrt{2}$ lies midway between the paraxial and marginal powers of the overall lens. On this basis, the add effect is simply $(b.y_{max}^2)/2$, so that for a 6 mm pupil and using the b values from equation (1) (i.e. -0.15 and -0.18D/mm^2), the "add" effects of the AO and PV "low" add lenses would be about 0.70D and 0.80D respectively, falling to around 0.30D and 0.35D for a 4 mm pupil).

The "mid" and "high" add PV and AO lenses have bi-aspheric designs, leading to different rates of power change for the central and peripheral portions. If we take the paraxial power of the central region as the "near" correction, and the power corresponding to the inner edge of the outer annulus as the "distance" correction, the addition then corresponds to their difference, being about 0.86D, 1.35D and 1.20D for the AO mid, AO high and PV high lenses, respectively.

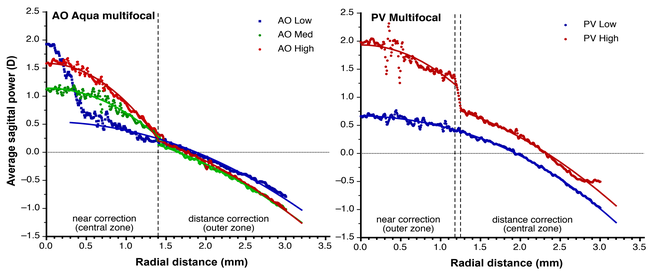

Figure 2: Power profiles for Air Optix Aqua and PureVision lenses. Note, that the abrupt increase in measured power over the central 0.3 mm zone of the AO Low is an artifact caused by dirt or a defect at the centre of the lens.

6. CONCLUSIONS

These measurements illustrate the diversity of power profiles found among current simultaneous image corrections and the difficulties in summarizing their performance in terms of near addition powers.

Overall, power profiles give considerable insight into the performance of simultaneous image CLs. If combined with knowledge of the ocular aberrations (particularly spherical aberration) and likely normal pupil diameter of the individual patient, power profiles can be valuable guides to the visual performance that the patient might achieve with different designs of lens.

3. RESULTS: Power maps

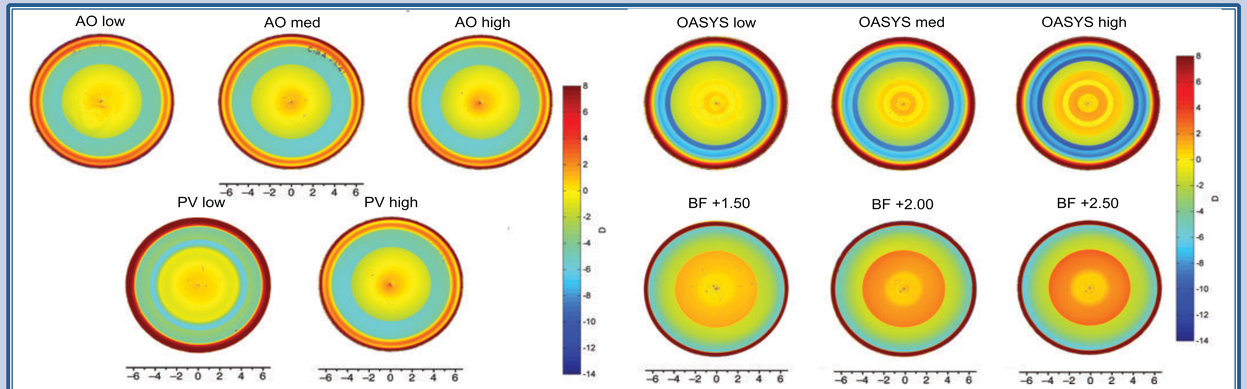

Figure 1: Colour-coded power maps for the multifocal lenses measured in this study with the Phase Focus Lens Profiler (Phase Focus Ltd, Sheffield, UK). The full areas of the lenses are mapped (the horizontal scales give distances in mm, the right-hand vertical scale the powers in D). The optical zones correspond to the sharply-bounded, central yellow/orange tinted areas (diameters about 6-7 mm).

5. RESULTS: Power profiles (concentric/aspheric – linear multifocals)

OASYS lenses display a series of concentric zones, separated by abrupt discontinuities: individual profiles can be constrained between two parabolically-decreasing curves: The lenses have distance powers corresponding to the central powers, i.e. +0.15, +0.58 and +0.46 D for the low, medium and high adds, respectively. The add powers correspond to the mean heights of the power steps and are 0.56, 0.73 and 1.48D, respectively.

Biofinity lenses have constant power over the central circular region of radius 1.5 mm, followed by an annular zone where the power increases approximately linearly, the gradient increasing with the add power, and finally an outer zone showing a slow, linear, increase in power with a gradient being almost independent of the add power. Thus it seems reasonable to take the nominal "add" as being the difference between the power of the central, distance zone and the inner edge (y = 2.1 mm) of the outer "near" zone. The estimated addition is 0.50, 1.03 and 1.18D for the nominally +1.50, +2.00 and +2.50D lenses.

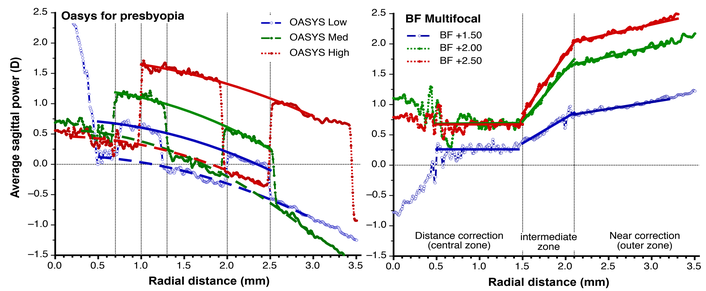

Figure 3: Power profiles for OASYS and Biofinity multifocals. Artifactual increases / decreases in power associated with the measurement technique occur at the cenrre of the OASYS Low add and the Biofinity +1.50D add lenses.

References

1. Maiden AM, Rodenburg JM, Humphry MJ. Optical ptychography: a practical implementation with useful resolution. Opt Lett 2010;35:2585-7.
2. Elder Smith AJ. Oxygen: are your corneae getting enough? In: Optometry Today CET. 16/10/12 ed; 2012. p. 45-8.3.
3. Plainis S, Atchison DA, Charman WN. Commenting on "Using Power Profiles to Evaluate Aspheric Lenses". Cont Lens Spectrum 2011;March/April 2011:15-7.

***Disclosure**: All measurements were made in Phase Focus Ltd.'s laboratories. All lenses were supplied by the manufacturers free of charge.*