"NON-ORTHOGONAL ASTIGMATISM"

Effect of correcting non-orthogonal corneal astigmatism with a novel optical system: 3 Case Studies

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BACKGROUND

For normal eyes, astigmatism is assumed to have orthogonal axes between its optical power meridians. Irregular (non-orthogonal) astigmatism is defined as having axes with less than 90° between them.

The eye condition Keratoconus generally results in non-orthogonal (NO) astigmatism and this cannot be fully corrected by conventional orthogonal optics. Objects viewed by people with significant NO astigmatism can present as multiple images or appear severely ghosted or distorted.

All ophthalmic spectacle lenses and toric contact lenses assume astigmatism has orthogonal axes, making it difficult to correct NO astigmatism optically. Additionally, topography machine software imposes orthognal axes on their power map outputs, so it is not possible to easily assess the extent of NO astigmatism present in any individual eye.

An investigation was undertaken to attempt to correct NO astigmatism with an appropriate optical system and assess the ffect on viausl acuity. Raw data was taken from scanning topography machines and processed to detect the natural maximum and minimum power meridians of the anterior and posterior cornea. Axial and tangential maps were created as well as power maps achieved through Light Ray Tracing

A means of creating spectacle trial lenses with NO power axes was developed and three sets made to use as refraction trial lenses. The axes of each set were orientated at 80°, 70° & 60° respectively and cyl powers -1.00DC to -6.00 DC in 1.00DC steps plus an additional -0.50DC lens.

Three subjects were chosen to be refracted by these lenses: two with mild keratoconus and one with longstanding, non strabismic ambylopia. They were refracted with each set of lenses, using a standard LogMAR Chart. The chart was changed randomly in between testing each set.

For each subject, the refraction starting point was taken from the orthogonal spectacle prescription. The subjects were refracted with NO cyls from each set of lenses and wre asked to locate the point of optimal acuity by rotating the lens. This was independently checked by the examiner.

To ensure that the subject was not experiencing a placebo effect, the lenses were randomly "flipped" during the examination. Unlike conventional cyl lenses, which present the same power meridians whichever way the lens is presented to the eye, NO lenses will present meridians at different axes when flipped which should cause an obvious difference in VA.

CASE 1 - SR MILD KERATOCONUS OS

SR (aet 45) has keratoconus (low cone) in the left eye, with prescription of:
OS Plano/-2.50 x 90 VA 6/6
This causes multiple visual distortions and ghosting effects.

The NO set of lenses with axes at 70° gave optimal VA with the following prescription: Plano @ 85/-2.50 @15 VA **6/4**

He reported clear sharp images with no ghosting or distortion.

When the lens was flipped (axes 110°) he could only obtain 6/9.The 70° axis option corresponded with the NO axes obtained using the Tangential map.

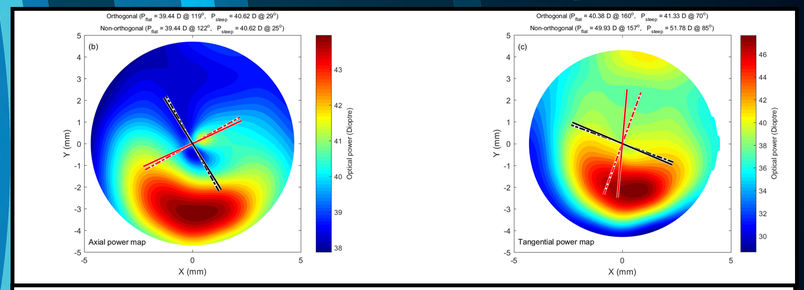

Fig 1 Axial power map showing NO axes at 97° (122°- 95°)

Fig 2 Tangential power map showing NO axes at 72° (157° - 85°)

CASE 2 – JC MILD KERATOCONUS OS

JC has mild keratoconus with the following prescription:
OS Plano/-2.25 x 90 VA 6/12 +2 with significant ghosting and visual distortion.

In this case, the NO set with axes at 60°gave optimal visual acuity with prescription of: -1.75@80/-2.50@140 VA 6/4

He attained a Snellen VA of 6/4 with no ghosting or visual disturbance. Acuity was confirmed in that flipping the lens gave VA of 6/12.

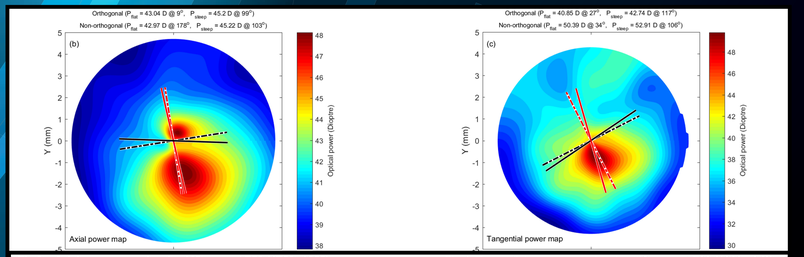

Fig 3 Axial power map showing NO axes at 75° (178°- 103°)

Fig 4 Tangential power map showing NO axes at 72° (106° - 34°)

In this case, all maps, including Light Ray Tracing, gave non-orthogonal axes near 70° but the preferred axis was at 60°

CASE 3 – NB OD AMBLYOPIA

NB (aet 40) has been amblyopic in the right eye since a child. Corneas showed no abnormalities and spectacle prescription was:

OD +2.75/1.75 x 90 VA 6/24 OS +1.75/-0.75 x 80 VA 6/6

She obtained optimal VA with the 60° lens set with a prescription of: OD +4.00 @10/-3.25 @130 VA 6/7.5.

Flipping the lens dropped the VA to 6/18 and she was able to attain 60 seconds arc 3D vision binocularly.

In this case, the non-orthogonal axes corresponded most closely to the Light Ray Tracing power map, suggesting the NO astigmatism might be lenticular, not corneal.

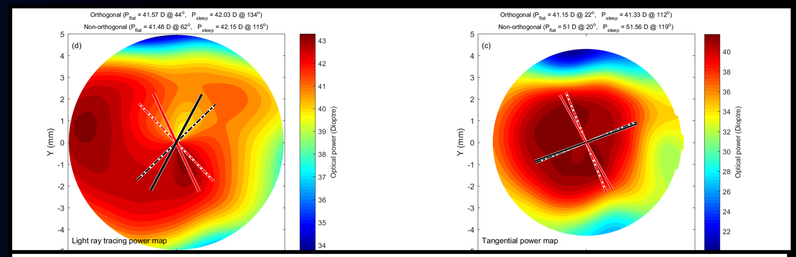

Fig 5 Light Ray Tracing map showing NO axes at 53° (115° - 62°)

Fig 6 Tangential power map showing NO axes at 99° (119° -20°)

CONCLUSIONS

At this early stage of investigation, only limited sets of non-orthogonal lenses were avaibale for testing and further sets with different designs and axes options will be manufactured for further investigation.

However, we have already shown that correcting for non-orthogonal astigmatism can improve Visual Acuity significantly. In two of the cases, the non-orthogonal axis corresponded with the tangential map and in the amblyopic case, there was more correlation with the Light Ray Tracing map which may suggest the involvement of the lens.

This has significance for the future correction of irregular corneas and amblyopia.

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