# Personal Experience in the Management of Irregular Astigmatism

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Irregular astigmatism is a relatively common condition which exists when the two steep astigmatism meridians of the opposite corneal hemidivisions differ in magnitude (asymmetry) or when they are not aligned at 180 degrees to each other (non-orthogonal) or both[1]. The typical topographic map displays an asymmetric and non-orthogonal bow-tie pattern **(Figure 1)** but in idiopathic occurrences can take on one of several appearances. Examples of irregular astigmatism include a) the primary corneal ectasias - keratoconus, keratoglobus, pellucid marginal degeneration b) post-corneal surgery and c) pathological – as a result of corneal infection. However, in most irregular corneas, there is an underlying quantifiable regular component of the astigmatism that is treatable symmetrically. This can commonly be gauged by the simulated keratometry value, and is also measured by manual keratometry.

While zero overall astigmatism is an ideal outcome of refractive laser surgery, this result is usually unattainable in eyes with irregular astigmatism due to a poorer correlation between corneal (topography or keratometry) and refractive (wavefront or manifest) astigmatism values compared to the values for a normal astigmatic population[1-4]. This prevailing difference between these two astigmatic parameters is quantified by the ocular residual astigmatism (ORA)[2, 3, 5] and in its presence, the eye's optical system cannot be corrected completely for astigmatism by refractive laser treatment.

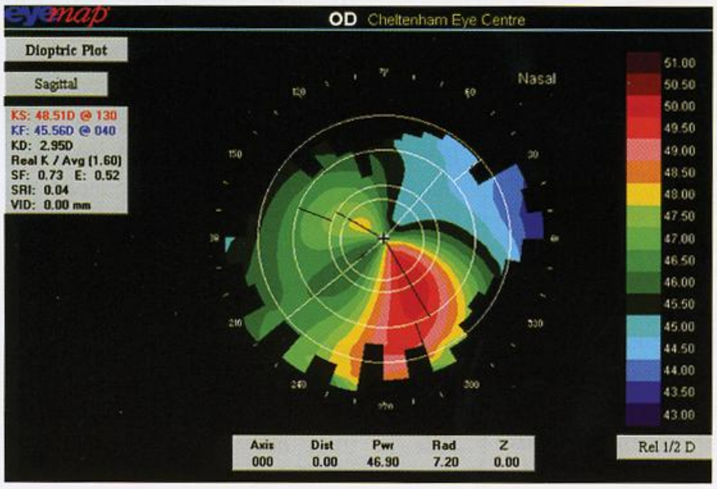


*Figure 1: Topography map displaying non-orthogonal, asymmetric bow-tie in irregular astigmatism.*

## Limitations of Treatments Based Solely on Wavefront or Topographic Data

### *Wavefront-guided treatments alone*

- leave an excessive and unnecessary amount of corneal astigmatism remaining (equivalent to the ORA) due to common difference in magnitude and/or axis between the refractive and corneal astigmatism.
- do not consider the patient's subjective appreciation of astigmatism, which is related to the visual cortex of the brain. The inclusion in the treatment of a patient's conscious perception of their refractive astigmatism is likely to benefit their satisfaction levels [6, 7, 8].
- correct all ocular aberrations at the corneal surface; which can result in corneal surface irregularities[8]. It is important to note that even eyes with normal (emmetropic) vision can suffer from aberrations that affect functional vision[9].

### *Topography-guided treatments alone*

- are derived from an objective measurement of the corneal astigmatism.
- also do not consider the fact that the amount of astigmatism derived from the cornea often differs from the refractive (second order) astigmatism.

## Combining Wavefront and Topographic Data Using Vector Planning

Using the method of vector planning[1-5, 8], both refractive and corneal information can be combined into the laser refractive treatment plan. The advantages of pre-operatively addressing both corneal and refractive astigmatism together reduces the amount of astigmatism that is left on the cornea compared to using refractive parameters alone and as a result, fewer second and third order aberrations would remain [2, 3, 5, 8, 10]. How much emphasis is placed on the ORA proportionately to completely reduce corneal versus refractive astigmatism can be determined by the surgeon. Conventionally, laser treatments are based on refraction parameters alone, leaving all of the ORA neutralised on the cornea postoperatively.

## Outcomes Using Combined Topographic and Refractive Parameters to Optimally Treat Astigmatism

In a retrospective study of 45 eyes with forme fruste or mild keratoconus the Alpins Method of vector planning was used for the treatment of astigmatism[2,3,5]. Due to the irregular shape of these corneas, surface ablation with Photo Astigmatic Refractive Keratectomy (PARK) was performed in each case. The mean astigmatism values preoperatively were -1.39DC +/- 1.08 by manifest refraction and 1.70D +/- 1.42 by topography. Postoperatively, 45 eyes were reviewed at 1 year, 32 eyes at 5 years and 9 eyes at 10 years for stability in the corneal astigmatism and refractive cylinder measurements. Average corneal keratometry values were also followed to identify signs of progressive ectasia.

In this study group, all eyes' treatments were optimized, that is, the emphasis on the ORA was determined by targeting reduced corneal astigmatism optimized to a with-the-rule orientation of the remaining astigmatism in a linear relationship. As a result a beneficial effect of less astigmatism remaining overall (corneal plus refractive measurements) was achieved after the surgery.

## Vector Planning - Individual Outcome

By incorporating the corneal parameters as well as the refractive astigmatism parameters into the overall treatment **(Figure 2)** less corneal astigmatism is being targeted as a result. Shifting the 'emphasis' for astigmatism reduction "to the left" (38% topography / 62% manifest refraction) increases the proportion of corneal astigmatism correction by aligning the treatment more closely to the principal corneal meridian[11]. The neutralization of the patient's ORA is apportioned between the refraction and the corneal readings. The targeted refractive astigmatism of 0.84D may not be fully evident to the patient perceptually. When measurements were in fact taken at six months simulated keratometry showed 1.25D @ 126 degrees while manifest refraction measured -0.25DC Ax 45 confirming the value of this optimised approach.

It is important to highlight that no matter what the percentage chosen on the 'emphasis' bar, the minimum amount of total astigmatism (corneal *plus* refractive), equal to the ORA, is being targeted at every point on the percentage scale. If the combined magnitude of the remaining astigmatism (corneal *plus* refractive) is greater than the initial ORA, the surgery then fails to achieve the maximum astigmatism treatment.

Even though all the astigmatism is not correctable from the visual system, results with this technique were still significantly better than they would have been using conventional refractive astigmatism values alone. Treatment using refractive parameters alone would theoretically result in 2.20D (that is, all the ORA) remaining on the cornea. Incorporating the corneal values reduced the total astigmatism in the system to 1.50D (1.25D corneal + 0.25D manifest refraction).

This particular patient also had an improvement in best corrected visual acuity (BCVA) from 20/20 to 20/15 as well as the improvement in unaided visual acuity (UCVA) from 20/200 to 20/20.

This favourable outcome of compounding the reduction of overall astigmatism was common in many cases within the group of 45 eyes and also evident in the aggregate results by incorporating topography into the treatment plan.

## Group Outcomes

Postoperative results at 12 months showed that, on average, we were able to reduce the corneal cylinder by an additional 0.68D, compared to results that would have theoretically been attained by treating refractive values alone. This was achievable without compromising the refractive outcome.

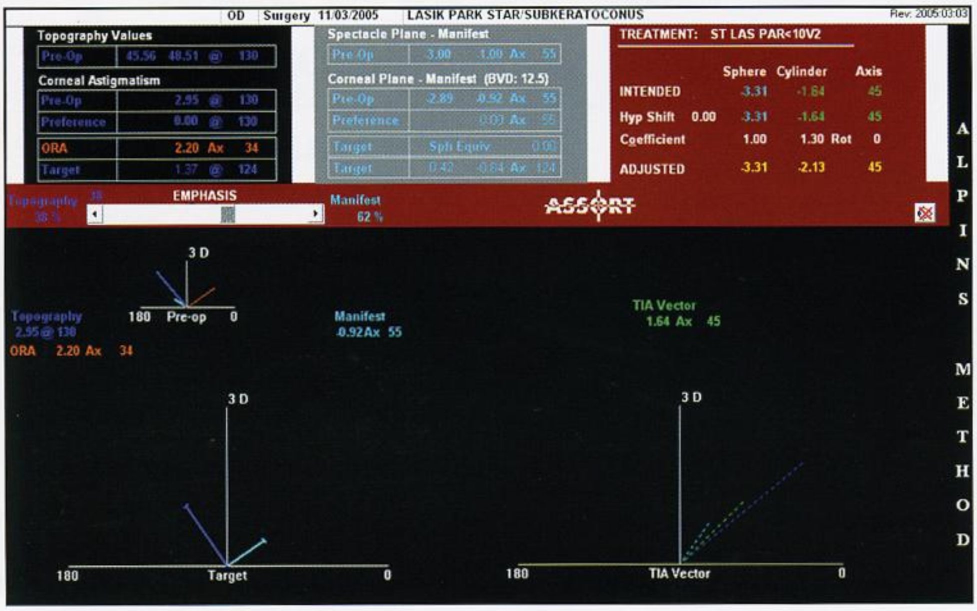


*Figure 2: ASSORT Treatment Planning - shows how the ORA of 2.20D Ax 34 is apportioned 38% to eliminating the topography astigmatism and 62% to the refractive cylinder. Furthermore, this ORA is neutralized by an equivalent 1.37D at the cornea and 0.84D at the spectacle refraction but at an orientation of 124 degrees.*

UCVA at 1 year postoperatively showed 100% of eyes ≥ 20/40, 89% of eyes ≥ 20/30, 56% of eyes ≥ 20/20. BCVA preoperatively and at 1 year was 89% ≥ 20/20 and 100% ≥ 20/30.

Gains and losses in BCVA revealed an excess of gain over loss: 1 eye had 2 lines loss, 6 eyes 1 line loss, 22 eyes unchanged, 13 eyes had 1 line gain and 3 eyes had 2 lines gain.

This treatment paradigm of combining corneal (topography or keratometry) parameters with refractive measurements has been shown to be safe and effective in this study of 45 eyes with forme fruste and mild keratoconus. These eyes postoperatively had a stable refraction and corneal topography over an extended period of time up to 10 years postoperatively. This is true both in terms of non-progression of disease and favourable spherical and astigmatic refractive outcomes.

No problems or adverse signs such as increase in corneal irregularity and progression of ectasia resulting in a reduction of UCVA or BCVA were detected.

Using the method of vector planning there is a potential for reduced higher order aberrations (coma and trefoil) with greater likelihood to achieve an improved best corrected visual acuity more frequently and avoid adverse symptomatic effects that would likely occur with treatments based solely on refractive values. However, patients with irregular astigmatism evaluated for photorefractive keratectomy should be carefully selected [12, 13] and followed over time to determine stability of manifest refraction and corneal topography. This ensures any eye with progressive or unstable disease is excluded from surgical intervention thus avoiding any adverse outcomes.

It is extremely unlikely that the treatment of irregular corneas as a result of keratoconus can achieve universally excellent outcomes without the inclusion of corneal parameters. The results achieved in the published series of 45 eyes with forme fruste or mild keratoconus demonstrate the importance and effectiveness of addressing the corneal shape in the treatment. The omission of this facility by using manifest or wavefront parameters alone is likely to leave a significant percentage of eyes with excess corneal astigmatism and consequently elevated higher order aberrations leading to some less than satisfactory outcomes.

## REFERENCES

For detailed and complete References, please visit our "Journal Bibliography" Section at our webpage: www.thehighlights.com