Refractive Lens Exchange for High Hyperopic Astigmatism Followed by LASIK

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Why Is This Case Relevant for the Refractive Surgeon?

This case highlights some of the interesting complications resulting from an unrecognised low correlation between corneal and refractive values in a refractive lens exchange. A refractive lens exchange with a toric IOL was called for in this case. Although one would have expected the toric implant to correct for corneal astigmatism, subsequent excimer laser surgery (LASIK) was necessary.

Case Background

A 47-year-old male underwent an excimer laser surgery assessment with the hope of achieving a level of unaided visual acuity suitable to enter the police force (which requires unaided 6/18 in better eye, 6/36 in other eye). He was found unsuitable for laser surgery due to a high amount of hypermetropia and astigmatism in his subjective refraction.

Unaided visual acuity	R 20/60	L 20/60
Subjective refraction	R +6.50/−5.75×95	L +6.00/−5.525×75
Cycloplegic refraction	R +7.25/−5.75×95	L +6.75/−5.25×75
Aided visual acuity	R 20/20 ++	L 20/20 ++
Topography (Sim K)	R 37.59/41.39 @ 7	L 37.44/41.46 @ 164
Keratometry	R 37.87/41.75 @ 13	L 37.75/41.62 @ 168

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J.L. Alió et al. (eds.), *Difficult and Complicated Cases in Refractive Surgery*,
DOI 10.1007/978-3-642-55238-0_7, © Springer-Verlag Berlin Heidelberg 2015

Internal and external examinations were normal with no evidence of cataracts.

The patient was advised to receive a refractive lens exchange procedure for each eye and counselled regarding the risks, side effects, near spectacle prescription required with a monofocal lens implant and the possibility of part-time spectacles postoperatively.

Uncomplicated bilateral same-day IOL surgery was performed using a Tecnis Toric Aspheric IOL.

OD: 2.2 mm incision at 193°; Tecnis ZCT400 +26.0 D SE 4.00 D CYL

OS: 2.2 mm incision at 0°; Tecnis ZCT400 +26.0 D SE 4.00 D CYL

Figure 7.1 displays the Assort toric planning module demonstrating the effect of placing the phaco incision at the steepest corneal meridian, reducing the corneal astigmatism, which now requires targeting with the toric IOL.

Figure 7.2 shows the effect of implanting a toric IOL with 24.00 D sphere, 4.00 D cylinder at an axis of 13°. The expected subjective refraction is shown under 'toric target' as '0.04/–0.08 × 103', indicating that we expect to under-correct the corneal astigmatism by 0.08 D at a meridian of 13°.

It is interesting to note that the IOL toric power at the lens plane of 4.00 DC converts to 3.30 D @ 103 at the corneal plane; this is calculated using the effective lens position and the A-constant from the SRK/T formula.

Ocular residual astigmatism (ORA) [1, 2, 3] was not calculated preoperatively.

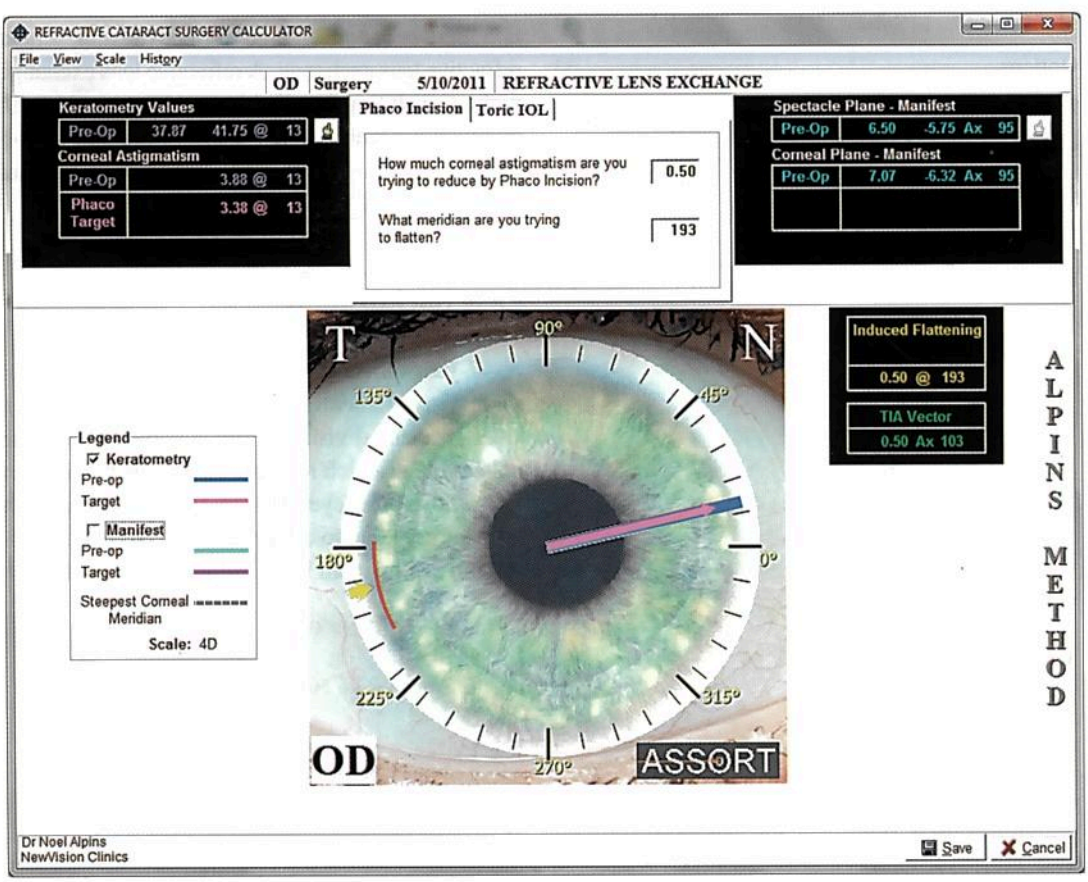

Fig. 7.1 Effect of the phaco incision on the preoperative corneal astigmatism of the right eye. Note that the flattening effect of the phaco incision of 0.50 D determined from previous cases reduces the preoperative astigmatism of 3.88–3.38 D

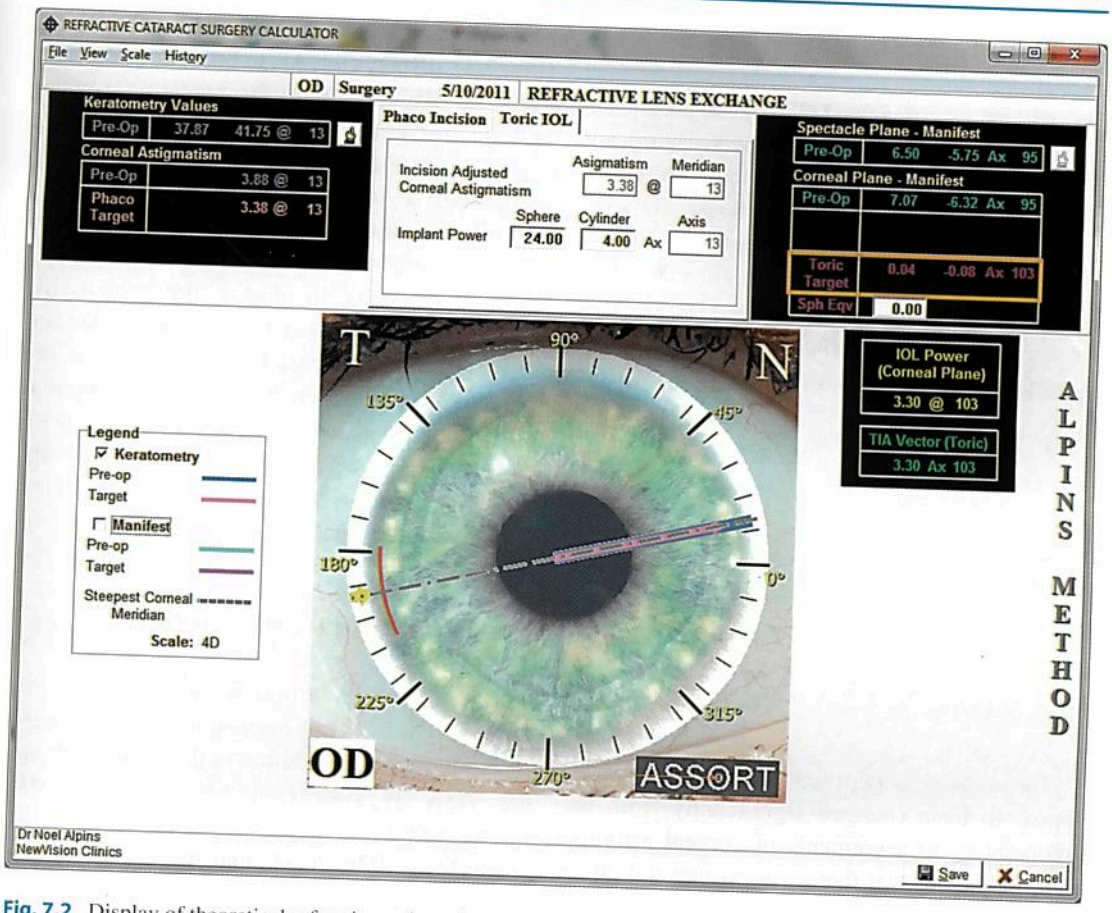

Fig. 7.2 Display of theoretical refractive astigmatism outcomes using a toric IOL of 24.00 D sphere and 4.00 D cylinder. The expected refractive cylinder is +0.08 D×13

Main Problem to Solve

The high degree of astigmatism remaining postoperatively in the subjective refraction in both eyes was a refractive surprise.

One month postoperatively:

Unaided visual acuity	R 20/40 –	L 20/80 –
Subjective refraction	R +0.25/–2.00×70	L +0.25/–2.25×50
Aided visual acuity	R 20/25 +	L 20/30 ++
Keratometry	R 38.25/41.60 @ 14	L 37.75/41.60 @ 170
Slit lamp	R IOL markings @ 13/193° as intended	L IOL markings @ 0/180° instead of 168/348°

Options

(a) Rotate the toric IOL to reduce the postoperative subjective cylinder.

(b) Explant the toric IOL and replace with a different toricity.

(c) Perform excimer laser surgery on the existing toric IOL to correct for the refractive astigmatism.

The toric IOL in the right eye was inconsistent in lining up exactly where it should have been (at 193°), resulting in a refractive cylinder of 2.00 D postoperatively. The toric IOL in the left eye was sitting 18° clockwise from its intended position of 168°, resulting in a 2.25 D refractive cylinder postoperatively.

Ancillary Tests

The patient was reviewed 2 months postoperatively to reassure refractive stability. No significant change in the subjective refraction was noted.

Slit-lamp examination showed the IOLs at exactly the same position as 1 month previously.

Calculation of preoperative ocular residual astigmatism (ORA), defined as the vectorial difference between the corneal and the refractive astigmatism (at the corneal plane), was:

ORA	R 2.27 D×116	L 2.66 D×91

The high ORA (>1.00 D) in both eyes indicated that rotating the IOL towards the refractive positive cylinder axis could reduce the manifest refractive cylinder.

Keratometry readings (2 months postop):

R 38.10/41.60 @ 14	L 37.75/41.75 @ 177

The manual keratometry parameters do not appear to have changed significantly from the preoperative measurements of corneal astigmatism, indicating that there was no unusual effect of the incision procedure on the cornea.

In analysing the outcome of a toric IOL procedure, it is important to compare the postoperative subjective cylinder (at the corneal plane) to the preoperative corneal astigmatism adjusted for any effect in magnitude and steep meridian by the phaco incision. Two overriding parameters must be calculated:

1. The Angle of Error (AE) [1, 2, 4, 5]: The angle between the intended astigmatic treatment vector (target-induced astigmatism vector – TIA) and the surgically induced astigmatism vector (SIA). This shows the degree that the IOL needs to be rotated for the minimum amount of spectacle cylinder to remain postoperatively.
2. The Magnitude of Error (ME) [1, 2, 4, 5]: The arithmetic difference between the magnitudes of the SIA and the TIA. This indicates whether the IOL implanted has over- or under-corrected the corneal astigmatism.

In this case, the toric IOL astigmatism analysis using the preoperative manual keratometry parameters adjusted for the phaco incision (Fig. 7.3), displays the AE to be +18° in the right eye. The ME was −0.49 D, indicating a minor under-correction of astigmatism in the right eye.

In the left eye, the AE was calculated as +20° and the ME as −0.67 D.

These analyses demonstrate an angle of error; the right eye is well positioned while the left eye is not. Considering the high ORA, rotation of the implant was not guaranteed to correct the cylinder remaining. Because the two eyes were inconsistent in IOL alignment and calculations, we decided to proceed with excimer laser surgery to most effectively reduce the refractive cylinder without rotating the implant.

Surgical/Medical Intervention

LASIK surgery was performed in the left eye 6 weeks post IOL toric implantation and 16 weeks post IOL toric implantation in the right eye using the ViSX S4 system and the Amadeus (*SiS*) microkeratome.

Right eye: Mixed astigmatism

Treatment parameters: −2.07 DS +2.37 DC×165°

This was converted to cross-cylinders to minimise the amount of corneal tissue removal:

Plano/+0.78×165 was treated at the cornea in the 5.0–9.0 mm zone.

Plano/−1.59×75 was treated at the cornea using an ellipse of 6.0×5.5 mm.

Left eye: Mixed astigmatism (with spherical shifts of astigmatism treatment included)

Treatment parameters (corneal plane): −2.26 DS +2.11 DC×140°

This was converted to cross-cylinders to minimise the amount of corneal tissue removal:

Plano/+0.34×140 was treated at the cornea in the 5.0–9.0 mm zone.

Plano/−1.77×50 was treated at the cornea using an ellipse of 6.0×5.5 mm.

Excimer laser treatments were based on 100 % refractive parameters. Vector planning, which incorporates both corneal and refractive parameters into the treatment plan, was not used as the corneal values were not relevant.

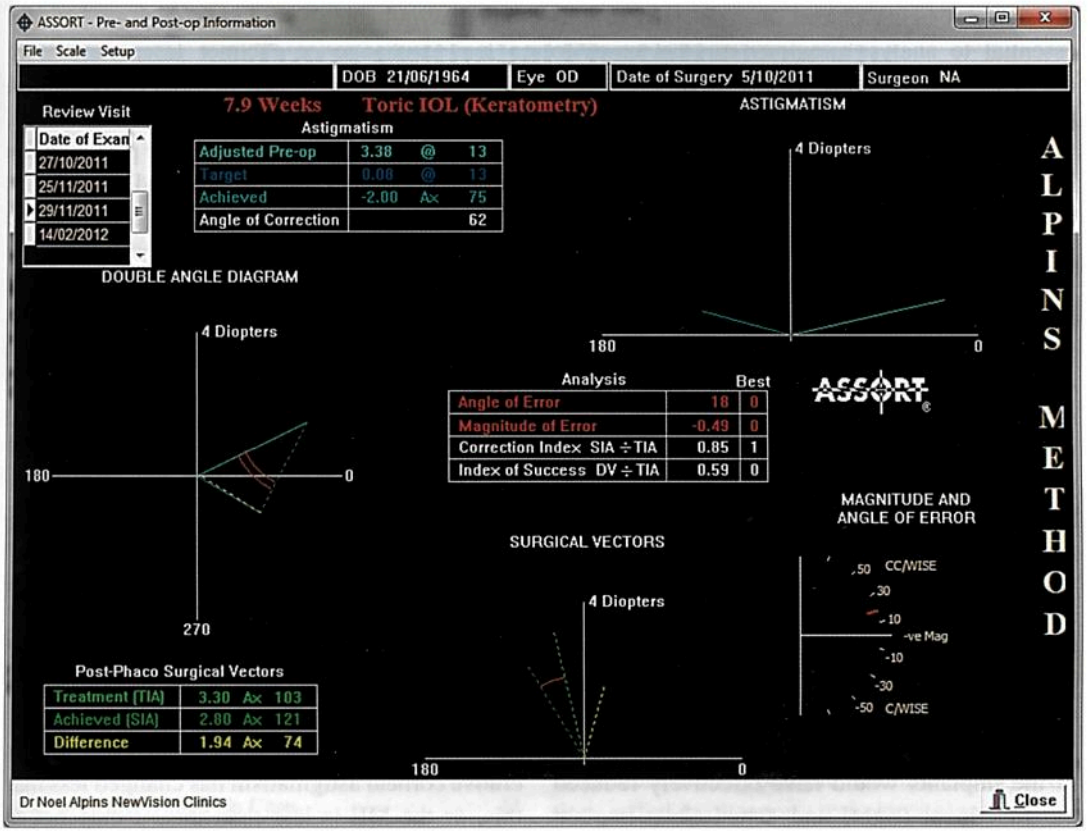

Fig. 7.3 Toric IOL astigmatism analysis displays an 'angle of error' of 18°, meaning that the IOL could be rotated clockwise 18° to reduce the postoperative refractive cylinder. The 'magnitude of error' is –0.49 D, indicating a minor under-correction of astigmatism with the toric IOL selected

Outcome

Three months after LASIK surgery in the right eye and 5 months after LASIK in the left eye (8 months after bilateral toric IOL implantation):

Unaided visual acuity	R 20/20–	L 20/25–
Subjective refraction	R +0.25/–0.25×75	L +0.75/–0.75×55
Aided visual acuity	R 20/20	L 20/20
Slit lamp (cornea)	R clear and quiet	L clear and quiet

The patient was extremely pleased with the outcome!

What to Learn from This Case

It is important to calculate the ORA presurgery (using the iAssort software: www.assort.com) to determine treatment possibilities, particularly LASIK or lenticular surgery which can remove the crystalline lens and lenticular astigmatism.

Given the excellent astigmatic outcomes of this case, we conclude that the ORA calculated preoperatively was likely due to lenticular astigmatism.

When planning for toric IOL surgery, it is important to factor into the lens choice any effect of the phaco incision on the preoperative corneal astigmatism. The magnitude of the toricity of the IOL may be more or less than that measured preoperatively, and the steepest corneal meridian may also have shifted as a result of the phaco

incision not being placed on axis. Hence, it is essential to analyse previous surgical cases to establish the flattening effect, if any, of your phaco incisions [2].

When assessing outcomes of toric IOL implants, the markings on the lens (which indicate the least power of the IOL) may be at the intended steepest corneal meridian, but mathematically this may not be the optimum axis of the IOL.

If there is a refractive surprise as indicated by a significant amount of cylinder remaining in the subjective refraction postoperatively, a toric astigmatic analysis must be performed, which compares the postoperative refractive cylinder (corneal plane) to the preoperative corneal astigmatism, adjusted for any effect of the phaco incision. The treatment in these cases is the IOL toricity at the corneal plane allowing for the effective lens position and the spherical component of the IOL. These calculations can be done using the ASSORT(R) toric IOL calculator (www.assort.com).

Perhaps early intervention and early rotation of the implants would have effectively reduced the functional (right) and actual (left) implant misalignment. However, there was concern that either one could have independently caused the remaining refractive cylinder.

There are essentially three options available to the surgeon:

1. Rotate the existing toric IOL to reduce the refractive cylinder to a minimum.

   Consider rotating the toric IOL when the AE is greater than 10°.
2. Exchange the IOL as the toric power selected is too strong or too weak.

   In cases where the ME is greater than 1.00 D, consider changing the toric IOL to a more suitable cylinder power selection.
3. Perform excimer laser surgery to correct for any unexpected cylinder in the subjective refraction.

It is important to note that if there is a coexisting spherical component postoperatively, this may influence a surgeon's decision between a lens exchange or excimer laser surgery. In cases where the preoperative ORA is greater than 1.25 D and the AE and ME are not significant, excimer laser surgery to correct the postoperative refractive cylinder may be indicated.

Importantly, before considering any of the above suggestions, it is necessary to establish that the phaco incision has performed as expected by measuring the corneal astigmatism postoperatively (topography or manual keratometry). This should be very similar to what you allowed for when determining the amount of astigmatism the toric IOL would neutralise and the steepest meridian that the toric IOL was aligned to. If the corneal astigmatism or the steepest meridian is now significantly different, with an unexpectedly large SIA, then all three options above should be reconsidered.

The significance of postoperative corneal and/or refractive astigmatism can be determined by the indicated steps of a toric IOL. If the toric IOL comes in 0.75 steps of cylinder and the postoperative corneal astigmatism has changed less than this, or the ME is less than this, it may not be beneficial to change to toric IOL.

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