Most practitioners acknowledge that rigid gas permeable (RGP) contact lenses offer superior vision to ametropic patients compared to soft lenses. In the majority of cases, fitting a spherical lens will correct patients to a high standard of visual acuity. However, there are occasions when spherical lenses do not provide an acceptable level of vision or comfort. This third article in a four-part series continues with a discussion about the basic concepts of RGP toric lens fitting, analysing indications to fit them, and exploring the various options available to the practitioner in fitting an astigmatic cornea.
Introduction

Fitting the astigmatic patient successfully often requires a toric RGP lens. The optics of these lenses is relatively straightforward – the key point being to analyse each meridian separately. RGP torics provide excellent visual acuity and durability, in a wide range of parameters. Possible disadvantages compared to soft lenses include some increase in chair time and initial reduced comfort. However, it should be mentioned that a significant number of patients trying RGP toric lenses will already be rigid lens wearers, where the barrier of discomfort will be negated.

The human cornea is neither a true spherical, nor a true toric surface, but is a relatively complex aspheric surface with the degree of asphericity varying in each of the principle meridians.\(^1\) Bennett and Rabbetts\(^2\) analysed the incidence of ocular astigmatism, and concluded that approximately 6% of the population has ocular astigmatism over 2.50 DC, which is the assumed level where RGP toric lenses are able to provide superior alignment on the corneal surface.

Soft toric contact lenses have advanced considerably over the last 10 years, both in design and production – indeed, they are now the preferred choice of practitioners for correcting astigmatism.\(^3\) However, there are still occasions in practice when soft toric lenses will not provide the ideal solution, that is irregular astigmatism, keratoconus and other irregularities of corneal topography.

Can spherical RGP lenses correct astigmatism?

So, what options are available to improve the fit and performance of a spherical lens (see Figure 1). There are no strict guidelines as to the exact amount of astigmatism which can be corrected with a spherical lens, some text books suggest it may be possible to achieve a satisfactory result up to 3.00D of corneal cylinder,\(^4\) while others put a figure of 1.50 to 2.00DC as being more realistic.\(^5\)

The important point is to recognise the signs and symptoms when a spherical lens is not working correctly:

<table>
<thead>
<tr>
<th>Terminology</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spectacle refraction</td>
<td>The spherical and cylindrical combination required, at a stated vertex distance, to correct the patient’s ametropia</td>
</tr>
<tr>
<td>Ocular refraction</td>
<td>The spectacle refraction adjusted by compensating for the back vertex distance (BVD)</td>
</tr>
<tr>
<td>Spectacle astigmatism</td>
<td>Can occur either from corneal and/or lenticular astigmatism. Measured in the spectacle plane</td>
</tr>
<tr>
<td>Ocular astigmatism</td>
<td>Taken directly from the spectacle astigmatism, after adjusting for the BVD</td>
</tr>
<tr>
<td>Corneal astigmatism</td>
<td>Astigmatism arising just from the cornea, and can be measured using a keratometer</td>
</tr>
<tr>
<td>Residual astigmatism</td>
<td>Residual astigmatism = ocular astigmatism – corneal astigmatism</td>
</tr>
<tr>
<td>Induced astigmatism</td>
<td>Induced astigmatism is created when a toric back surface is placed on a toric cornea. It is characterised by the differing refractive indices of the contact lens and the tear film beneath</td>
</tr>
</tbody>
</table>

Table 1 Commonly used definitions regarding RGP toric lenses.
• The comfort of a RGP lens is reduced when the area of alignment is reduced; the excessive edge clearance leading to unwanted lid interaction with the lens.
• 3 and 9 o’clock staining (see Figure 2) will often be evident in patients having both ‘with’ and ‘against the rule’ astigmatism, due to a lack of lens movement caused by reduced edge clearance.
• Poor centration may occur. If ‘against the rule astigmatism’ is present, the lens will decentre horizontally, whereas in ‘with the rule astigmatism’, the lens will ‘rock’ along the steeper meridian, or decentre downwards.
• Lens flexure may occur if the lens is not fitted in alignment with the flattest corneal meridian.
• Corneal moulding, which in turns leads to spectacle blur, may also be apparent – this is induced when the differential bearing effect of a spherical lens on a large astigmatic cornea leads to an unwanted alteration in the refraction after removal of the lens.
• Residual astigmatism may also occur (see Table 1).

There are several design options available to improve the alignment of spherical RGP lenses and the patient’s tolerance to them:
• Choosing a lens with smaller total diameter will help to minimise the exaggeration between the two different meridians on the corneal surface, which in turn will help to avoid the excessive edge clearance in the steeper meridian. It is also possible that the central cornea will be more spherical than the periphery – again, justifying fitting a lens with a reduced total diameter. However, this remedy needs its own caution, as smaller diameter lenses often feel more uncomfortable, and will inevitably signify a smaller Back Optic Zone Diameter (BOZD), which may lead to concerns about flare.
• Aspheric lens designs generally have a narrow edge lift and give reduced edge clearance along the steeper meridian, which should encourage the lens to centre more accurately, and give a better visual result.
• Some practitioners believe that steepening the Back Optic Zone Radius (BOZR), to a new value a third, or halfway, between the principal meridians, will create a more stable fitting lens, however, research tends to suggest that this is not a creditable method.

Indications to fit toric RGP lenses
When the various methods utilising spherical RGP lenses are not producing the desired results, then the practitioner must turn their attention to fitting a toric RGP lens (see Table 2). There are only two indications why RGP toric lenses are used:
1. A better physical/mechanical fit of the lens on an astigmatic cornea. This will typically occur when corneal astigmatism is greater than 2.50 to 3.00 DC. In this situation, a back surface toric lens will be fitted to negate the irregular corneal topography. As a guide, it is assumed that approximately 6% of all RGP fittings will need to be back surface torics.
2. A spherical back surface gives an aligned fit, however, due to a significant amount of residual astigmatism (see Table 1), the vision correction is compromised.

Patient selection
There are various considerations to take into account when recommending and selecting RGP toric lenses. These would include:
• Patients who have difference in principal meridians from keratometer readings greater than 0.6mm.
• A spherical lens is unstable, or decentring to an unacceptable level.
• High refractive astigmatism, where the cylinder power is >2.00DC, or residual astigmatism is over >1.00DC.
• The patient’s cornea becomes significantly more toric towards the periphery.
• The patient experiences poor comfort with spherical RGP lenses.
• Large amounts of lens flexure.
• Patients may experience excessive deposition or desiccation with soft contact lenses.
Toric periphery
A peripheral toric design should be considered when the cornea is more astigmatic at the periphery, and using a lens of smaller total diameter does not give the desired result. Best clinical results are achieved when corneal and ocular astigmatism is approximately equal, and <3.00DC. Stabilisation is better when the difference in the peripheral curves are 0.6mm or greater, and it is recommended that the difference between the BOZD and the total diameter (TD) is at least 2.0mm. A typical fitting method would include the following:
- Take keratometer readings as usual
- Use a spherical trial lens, to give an aligned fit on the flattest corneal meridian
- The K-readings can be used to determine the radius of the steeper meridian, along with the use of axial edge tables to finalise the peripheral curves for each principal meridian, or it may be possible to determine the fit from the fluorescein pattern

- The secondary curves are usually 0.80 to 1.20mm flatter
- Final acuity should be good, due to the fact that the corneal astigmatism is neutralised by the tear lens.
For example, see Table 3 (page 50).

Back surface torics
These lenses have a toroidal back surface and theoretically a spherical front surface, although in reality, most lenses are manufactured with a compensating front toric surface. Stabilisation is not necessary with this design of lens, since the lens radii should align with the principal meridians of the cornea.

When fitting these lenses, there are three methods that practitioners can follow:

Spherical trial lens
A diagnostic lens is applied to the eye to give alignment along the flattest meridian, and the steeper meridian is determined from the K readings. The power along the flattest meridian is obtained from an over-refraction. The power of the cylinder is obtained by calculation, taking into account the residual astigmatism from the spherical lens along with the induced astigmatism created by the toric back surface.

Toric fitting set
A diagnostic lens is applied, where the flattest meridian is aligned to the flattest meridian of the cornea, and the steeper meridian 0.10 mm flatter than the steepest K reading. The power along the flattest meridian is obtained by an over-refraction. The power of the cylinder is obtained by calculation, taking into account the residual astigmatism from the spherical lens along with the induced astigmatism created by the toric back surface.

Empirical fitting
Arguably the best and simplest method for practitioners, particularly if inexperience is a limiting factor, is to telephone the technical or professional services of their chosen manufacturer. Most laboratories will need to be provided with spectacle refraction, along

Table 2 Clinical pearls for fitting RGP lenses to astigmatic eyes.

<table>
<thead>
<tr>
<th>Type of astigmatic correction</th>
<th>Clinical tip</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>K readings should be carefully checked (special consideration to see if ocular and corneal axes match) Adaption may be required even for existing RGP wearers due to the extra thickness, particularly if prism ballast or truncation is used Manage patient expectations More appointments than usual may be necessary Make use of the technical support of the manufacturers There will be situations where soft toric lenses are the better option</td>
</tr>
<tr>
<td>Spherical lenses</td>
<td>Explore the option of fitting the patient with a spherical lens first Fitting a smaller diameter reduces the effect of corneal astigmatism</td>
</tr>
<tr>
<td>Back surface torics</td>
<td>Back surface torics over-correct the corneal astigmatism due to induced astigmatism An aligned fitting back surface toric lens should not need any stabilisation A rotating back surface toric will only cause visual problems if it has been corrected for residual astigmatism (alignment bitoric) Computer programs are available to save time with lengthy and laborious calculations Empirical fitting with back surface torics will give a high standard of first time success Toric lenses are thicker than spherical lenses – it is recommended to use a higher Dk material</td>
</tr>
<tr>
<td>Front surface torics</td>
<td>Front surface torics may be required to improve VA where residual astigmatism is present If only one eye requires a front surface toric, prism ballast stabilisation may disturb binocular vision Front surface stabilisation methods may induce flare due to inferior decentration Toric lenses are thicker than spherical lenses – it is recommended to use a higher Dk material</td>
</tr>
</tbody>
</table>

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with the back vertex distance (BVD), as well as the K readings (to two decimal places). From these data, the laboratory will be able to produce a lens. There are many computer programs commonly being used which take into account all the above information and factor it into the equation refractive index of the contact lens, and induced astigmatism, to simplify the process.

For a greater understanding of the explanation it would be useful to follow the worked example in tables 3 and 4:

- For BOZD between 7.00 and 7.40, each principal BOZR is fitted 0.05mm flatter than K readings
- For BOZD between 7.40 and 8.00 each principal BOZR is fitted 0.10mm flatter than K readings
- Total lens diameter is usually 1.50 to 2.00mm less than HVID.

The ideal lens fit should show the same fluorescein pattern as a spherical lens on a spherical cornea (see Figure 3).

From the above example, the amount of induced astigmatism was -1.23DC and therefore cannot be ignored. Consequently, two strategies can be used to compensate for it:

1. Changing the back surface radii
   - Provided the ocular astigmatism is greater than the corneal astigmatism, it is possible to reduce the difference between the two principal meridians, and this will reduce the effect of the induced astigmatism. The aim is to get the residual amount below 0.75DC. In practice this can often be achieved by slightly flattening the steeper meridian. This may also encourage a better tear exchange between the lens surface and the cornea.

2. Bitoric lenses
   - In the example above, the ocular astigmatism was equal to the corneal astigmatism, so the option here is to fit a bitoric RGP lens, where the front surface would be ‘worked’

### Table 3 Working example 1.

<table>
<thead>
<tr>
<th>Ocular refraction</th>
<th>-2.00/-2.50 x 180</th>
</tr>
</thead>
<tbody>
<tr>
<td>K readings</td>
<td>7.80mm along 180</td>
</tr>
<tr>
<td></td>
<td>7.30mm along 90</td>
</tr>
<tr>
<td>HVID</td>
<td>11.50mm</td>
</tr>
<tr>
<td>Corneal astigmatism</td>
<td>7.80 – 7.30 = 0.50mm (rule of thumb 0.10mm = 0.50D) = 2.50D</td>
</tr>
<tr>
<td>Residual astigmatism</td>
<td>-2.50 – (-2.50) = 0.00DC</td>
</tr>
<tr>
<td>Total lens diameter</td>
<td>9.60mm BOZD: 7.50mm</td>
</tr>
<tr>
<td>BOZD</td>
<td>7.50mm</td>
</tr>
</tbody>
</table>

From the guidelines above, the following BOZR: 7.90mm along 180 (r2), 7.40mm along 90 (r1)

Induced astigmatism (I) = n - n' - n – n'
                        r1          r2

Lens astigmatism induced by the back surface in air (A) = 1 – r'1 - 1 – n'
                      r1          r2

where:
- n = refractive index of tears (1.336)
- n' = refractive index of RGP lens material (1.480)
- r1 = Steeper of BOZR in metres
- r2 = Flatter of BOZR in metres

BVP along flatter meridian is ocular refraction sphere (S)
BVP along steeper meridian is S + A - I

Induced astigmatism = -144 - 144
                        7.40 7.90

= (-19.46) - (-18.23) = -1.23D

Lens astigmatism in air = - 480 - 480
                        7.40 7.90

= (-64.86) – (- 60.76) = -4.10D

BVP along flatter meridian = -2.00D
BVP along steeper meridian = (-2.00) + (-4.10) - (-1.23) = -4.87D
Equivalent to -2.00/-2.87 along flatter meridian.

### Table 4 Working example 2.
due to the presence of significant residual astigmatism, a toroidal front surface is required to satisfactorily correct the vision. In order to maintain the correct axis, stabilisation will be required. A typical method for fitting would be as follows:

- Take K readings, measure HVID
- Apply a spherical lens to fit aligned to the flattest meridian
- Assess the fit of the lens (appearance similar to a spherical RGP lens)
- Over refract patient, both sphere and cylinder
- Determine the method and amount of stabilisation, prism ballast of 1.5Δ base down would be usual for cylinders up to approximately 2.00 DC, anything over this may require 2.0 to 3.0Δ
- Make an estimate of lens rotation, this is typically 5 to 10 degrees nasally
- Order the lens from the laboratory, remembering to ask it to dot the lens so that rotation can be checked and recorded. For example, see Table 5.

There are two methods of stabilisation commonly used: prism ballast and truncation. Prism ballast uses between 1.5 and 3.0Δ which enables the base of the prism to be at the lowest point of the lens, due to the ‘melon seed’ principle exerted by the eyelids, the same methodology is used by some soft toric lenses. While this is the more popular method used by practitioners, it has two potential disadvantages, namely the thicker lower edge may cause the lens to be more uncomfortable, and may cause the lens to drop. Truncation is achieved by removing a tangent of about 0.50 to 1.00mm from the edge of the lens, and can either be the lower or upper edge; again the potential drawback will be symptoms of discomfort.

Front surface torics
This is essentially a spherical back surface RGP lens which gives a good aligned fit, but available, and are fitted to correct both the induced and residual astigmatism. The design of this lens means that any significant rotation will cause a reduction in visual quality.

Front surface torics
This is essentially a spherical back surface RGP lens which gives a good aligned fit, but

### Table 5 Working example 3.

<table>
<thead>
<tr>
<th>Spectacle refraction</th>
<th>-1.50/-2.00 x 90</th>
</tr>
</thead>
<tbody>
<tr>
<td>K readings</td>
<td>7.90mm along 90</td>
</tr>
<tr>
<td></td>
<td>7.80mm along 180</td>
</tr>
<tr>
<td>Trial lens applied</td>
<td>7.90/7.50/9.50</td>
</tr>
<tr>
<td></td>
<td>BVP -3.00</td>
</tr>
<tr>
<td>Over refraction</td>
<td>+1.50/-1.50 x 90</td>
</tr>
<tr>
<td>Lens to order</td>
<td>7.90/7.50/9.50 AEL 0.12 BVP -1.50/-1.50 x 90</td>
</tr>
<tr>
<td></td>
<td>1.5Δ base down, dot prism base, Dk 60</td>
</tr>
</tbody>
</table>

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