# TORIC RGP LENS FITTING

## Indications for use

The main uses of toric lenses are as follows:

1. To improve the vision in cases where a lens employing spherical front and back optic zone radii is unable to provide adequate refractive correction due to the presence of significant residual astigmatism.

2. To improve the physical fit in cases of high corneal toricity where a lens with a spherical back optic zone radius (BOZR) and spherical back peripheral zone radii fails to provide an adequate physical fit.

These two main uses of toroidal surfaces on contact lenses are not always distinct, such that occasionally a toric lens will be used for both physical and optical reasons. For example, when fitting an eye with both a high degree of residual astigmatism and a large amount of corneal toricity, a toric RGP lens is required optically (to correct the residual astigmatism) as well as physically (to optimize the fit of the lens).

## Fitting principles

*Back Optic Zone Radii (BOZR)*
Use a toroidal back optic zone with the steeper radius fitted slightly flatter (longer radius) than the corresponding corneal radius so as to assist the interchange of tears. The flatter radius will generally be fitted 'on K' or else a little steeper than its corresponding corneal radius. In this way, there will be reasonable alignment between the lens and cornea, while at the same time providing for adequate tear interchange.

The back optic zone radii should always be chosen such that the difference between the flat and steep radii is 0.3mm or greater. Otherwise, the toroidal BOZR may not position properly on the toroidal cornea leading to lens rotation and possible visual disturbance depending on the type of toric lens design.

*Total Diameter (TD)*
Lens diameter is determined as for a spherical RGP lens, with particular attention being given to lens centration, lens movement and the appropriate lid interaction with the lens.

*Back Optic Zone Diameter (BOZD)*
This will usually be 75-85% of the lens diameter.

*Back Peripheral Radii (BPR)*
The peripheral curves will usually have the same degree of toricity as the BOZR (in other words, the difference in the toroidal peripheral curve radii will be the same as the difference in the toroidal BOZR). For example, if a practitioner usually specifies the secondary curve 0.9mm flatter than the BOZR for a spherical lens, then for a lens with toroidal BOZR of 7.90/7.40, the secondary curve ordered would be 8.80/8.30.

*Centre Thickness*
Toric contact lenses will generally be a good degree thicker than the spherical form, so initially patients may notice greater discomfort with the former.

## Optical considerations of toroidal back optic zones

**Calculation of back vertex power (BVP)**
Calculating the back vertex powers for a RGP lens with toroidal back optic zone involves the same basic principles as for determining the BVP for a spherical lens. For spherical lenses, the power of the contact lens in air plus the power of the tear lens in air should add up to the ocular refraction. With toric lenses, the same rule applies, but here the two separate meridians must be considered.

The BVP can be determined in two ways:

*Empirically*
In this case, the BVP is calculated using the patient's keratometry readings and ocular refraction. The formula used is simply based on the principle that the power of the contact lens in air plus the power of the tear lens in air should add up to the ocular refraction. The formula must be applied in both meridians.

i.e. Ocular refraction = $BVP_{cl} + BVP_{tears}$ $\qquad$ $F_{oc}$ = ocular refraction

where $BVP_{cl}$ is the power of the contact lens and $BVP_{tears}$ is the power of the tear lens.

Rearranging we get $\qquad$ $BVP_{cl}$ = Ocular refraction - $BVP_{tears}$

The power of the tear lens is obtained from the following formula $\qquad$ $BVP_{tears} = \left(\frac{336}{BOZR} - \frac{336}{K}\right)$

**Example 1**

Ocular refraction: +2.50/-3.75 x 180

Keratometry reading: 8.60mm (39.25D) along 180
7.85mm (43.00D) along 90

BOZR of 8.50mm and 7.90mm are chosen to fit the horizontal and vertical meridians respectively.

Along 180,

$BVP_{tears}$ = +0.50D

$BVP_{cl}$ = +2.50 - 0.50 = +2.00D

Along 90,

$BVP_{tears}$ = -0.25D

$BVP_{cl}$ = -1.25 - (-0.25) = -1.00D

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|---|---|---|---|---|
| The final powers are written as follows: | 8.50/+2.00<br>7.90/-1.00 | or | 8.50/7.90<br>+2.00/-1.00 | <u>and not as</u> +2.00/-3.00 x 180 |

*Based on refraction over a diagnostic lens*

In this case, the BVP is determined based on the refraction over a diagnostic trial lens. The power determination is performed the same as with a spherical RGP lens, except that you are working with two meridians instead of one. Note that you only need perform <u>one</u> over-refraction to calculate the BVP along both meridians. The following formulae are applicable and again they must be applied in both meridians.

$$BVP_{cl} = BVP_{trial} + \text{Over-refraction} - \Delta\text{tear lens power}$$

where $BVP_{trial}$ is the power of the trial lens and Δtear lens power (the change in tear lens power) is given by

$$\Delta\text{tear lens power} = \left(\frac{336}{BOZR_{final}} - \frac{336}{BOZR_{trial}}\right)$$

where $BOZR_{final}$ is the back optic zone radius we have chosen for the lens we are going to order and $BOZR_{trial}$ is the back optic zone radius of the trial lens.

**Induced astigmatism**

Induced astigmatism is the astigmatic effect created in the contact lens/tear lens system by the toroidal back optic zone bounding two surfaces of different refractive index, namely the lens (refractive index 1.41 to 1.49 depending on the material) and the tears (refractive index 1.336).

It should be noted that the front surface cylinder correction for the induced astigmatism is automatically incorporated into the lens when the practitioner calculates the back vertex powers for the toric RGP lens.

Consider the toric lens designed in example 1 (final Rx 8.50/7.90 +2.00/-1.00)

Specification of these BVP (+2.00D and –1.00D) along with the respective BOZR (8.50mm and 7.90mm) will *automatically* bring about the incorporation of the front surface cylinder to correct for the induced astigmatism. This can be confirmed by calculating the resultant front surface powers: +56.6@180, +57.8@90 (let n=1.47 and t=0.3mm).

Hence, the total power of the front surface is +56.6DS with +1.2DC x 180. This front surface cylinder represents the correction for the induced astigmatism.

The correction for the induced astigmatism is always a plus cylinder with same axis as the flatter principal meridian of the cornea. The magnitude of the induced astigmatism is directly proportional to the degree of contact lens toricity and the refractive index of the lens material.

Induced astigmatism can be calculated by the following formula:

$$\frac{1000(1.336 - n_{cl})}{BOZR_{fl}} - \frac{1000(1.336 - n_{cl})}{BOZR_{st}}$$

where $n_{cl}$ = the refractive index of the lens material (usually somewhere between 1.41 and 1.49) and $BOZR_{fl}$ and $BOZR_{st}$ are the BOZR along the flat and steep meridians of the contact lens respectively.

Using this formula for the previous example, induced astigmatism = 1.20D.

It is often thought that the induced astigmatism created by using a toroidal back optic zone surface on an eye with corneal astigmatism and residual astigmatism will fortuitously cancel out the residual astigmatism. In practice, however, this will only occur in a small percentage of cases. Indeed, the induced astigmatism usually exaggerates the effect of the residual astigmatism.

**Spherical power equivalent (SPE) bitoric lenses**
These are lenses which do not correct for any residual astigmatism. They are bitoric because the front surface contains a cylinder solely for the correction of the induced astigmatism. They are sometimes referred to as compensated bitoric lenses. The lens designed in Example 1 would be classed as a compensated bitoric lens.

**Cylindrical power equivalent (CPE) toric lenses**
All other types of toric RGP lenses come under this classification and the one thing these lenses have in common is that they incorporate a correction for residual astigmatism. With all cylindrical power equivalent bitoric lenses, some visual disturbance will occur with rotation as the axis of correction for the residual astigmatism remains fixed in relation to the eye.

This category can be further subdivided as follows:

*Alignment bitorics*
These have both a toroidal front and back surface. The front surface incorporates correction for residual astigmatism as well as for the induced astigmatism. In addition, the axes of the spectacle refraction over the lens correspond with the principal meridians of corneal curvature, so the correction for the residual astigmatism will be along one of the principal meridians of the lens (hence the name 'alignment bitoric'). As such, the use of the term alignment bitoric here should not be confused with alignment in regard to lens fitting.

**Example 2**

| | |
|---|---|
| Ocular refraction: | -1.00/-2.00 x 165 |
| Keratometry reading: | 8.04mm (42.00D) along 180 |
| | 7.50mm (45.00D) along 90 |
| Diagnostic BOZR | 7.95 |
| Diagnostic BVP | -1.00D |
| Over-refraction | +0.50/-1.00 x 80 |

BOZR of 8.00mm and 7.55mm are chosen to fit the horizontal and vertical meridians respectively.

In this case, there is residual astigmatism equal to -1.00DC x 80 and the axes of the spectacle refraction over the lens (80 and 170) do not correspond with the principal meridians of the cornea (90 and 180). As a rule, it is rare for the axis of the residual astigmatism to correspond exactly with one of the principal meridians of the cornea.

The best solution to this problem, and one that works well in practice, is to make an approximation and assume that the axes of the spectacle refraction over the lens do correspond with the principal meridians of corneal curvature.

Consequently, the axis of the residual cylinder is now assumed to be at 90 rather than at 80, therefore simplifying calculations. We then proceed to calculate the BVP by using the over-refraction method.

Along 180,

$$\Delta\text{tear lens power} = \left(\frac{336}{8.00} - \frac{336}{7.95}\right) \sim -0.25\text{D}$$

$BVP_{cl}$ = -1.00 - **0.50** - (-0.25) = -1.25D

Along 90,

$$\Delta\text{tear lens power} = \left(\frac{336}{7.55} - \frac{336}{7.95}\right) \sim +2.25\text{D}$$

$BVP_{cl}$ = -1.00 + **0.50** - 2.25 = -2.75D

The values for the over-refraction are in bold to emphasize the fact that there is residual astigmatism present in this case. In other words, the over-refraction along 180 is not equal to the over-refraction along 90.

*Back surface torics*
These have a toroidal back surface but a spherical front surface. The design principle is similar to that for alignment bitorics. As with alignment bitorics, the front surface incorporates correction for residual astigmatism as well as for the induced astigmatism and the correction for the residual astigmatism is along one of the principal meridians of the lens.

In the case of a back surface toric lens, however, the correction for the residual astigmatism is equal and opposite to the correction for the induced astigmatism. Hence the two required cylindrical corrections cancel each other out, meaning that the front surface is left spherical.

Very occasionally a case of induced and residual astigmatism cancelling out one another occurs, as in the following example.

**Example 3**

| | |
|---|---|
| Ocular refraction: | +3.00/-4.00 x 180 |
| Keratometry reading: | 8.04mm (42.00D) along 180 |
| | 7.50mm (45.00D) along 90 |
| Diagnostic BOZR | 7.95 |
| Diagnostic BVP | +1.00D |
| Over-refraction | +1.50/-1.00 x 180 |

BOZR of 8.00mm and 7.55mm are chosen to fit the horizontal and vertical meridians respectively.

In this case, the correction for the residual astigmatism is equal to -1.00DC x 180.

The induced astigmatism can be calculated using the formula previously shown:

$$\text{Induced astigmatism} = \frac{-134}{8.00} - \frac{-134}{7.55} = 1.00\text{D} \text{ (assume n = 1.47)}$$

The correction for the induced astigmatism is always a plus cylinder with same axis as the flatter principal meridian of the cornea (in other words, the same axis as the corneal cylinder). Hence, in this example, the induced astigmatism will be corrected by +1.00DC x 180.

The residual astigmatism correction is -1.00DC x 180, so the residual astigmatism and the induced astigmatism should cancel each other out. This can be confirmed by calculation of the back vertex powers and the front and back surface powers of the lens (assuming a lens centre thickness of 0.25mm).

Along 180,

$$\Delta \text{tear lens power} = \left(\frac{336}{8.00} - \frac{336}{7.95}\right) \sim -0.25\text{D}$$

$BVP_{cl}$ = +1.00 + 1.50 - (-0.25) = +2.75D

Front surface power of the contact lens = +60.86D

Along 90,

$$\Delta \text{tear lens power} = \left(\frac{336}{7.55} - \frac{336}{7.95}\right) \sim +2.25\text{D}$$

$BVP_{cl}$ = +1.00 + 0.50 - 2.25 = -0.75D

Front surface power of the contact lens = +60.86 = front surface power along 180

The front surface is spherical (same power along both principal meridians) so the residual and induced astigmatism have indeed cancelled each other out.

A back surface toric design is only possible if the residual astigmatism is *equal* and *opposite* to the correction for the induced astigmatism. In practice, this situation will only present itself in a small percentage of cases.

*Oblique bitorics*
As with alignment bitorics, these have both a toroidal front and back surface. With oblique bitorics, however, the principal meridians of the toroidal back and front surfaces are not parallel, due to a difference between the axes of the spectacle refraction and the principal meridians of corneal curvature.

*Front surface torics*
These have a toroidal front surface and a spherical back surface. They are generally used when there is significant residual astigmatism but minimal corneal astigmatism, so a toroidal BOZR is not an option due to reasons of rotation and stability. Other forms of lens stabilization, such as prism ballast or truncation, are required.

**Differentiating between a SPE and CPE toric lens**
Given a toric RGP lens, how can we tell if it is a spherical power equivalent (SPE) or cylindrical power equivalent (CPE) lens? This is done easily by comparing the contact lens toricity and the air cylinder.

The contact lens toricity is the toricity of the contact lens with respect to the eye and is obtained by the calculation 336/$BOZR_1$ - 336/$BOZR_2$. If the BOZR are specified in dioptres, the contact lens toricity is simply obtained by subtracting the flatter BOZR from the steeper BOZR. The air cylinder is the toricity of the contact lens in air (as measured on the vertometer).

For a compensated bitoric (SPE) lens, the contact lens toricity is equal to the air cylinder.

In Example 1, contact lens toricity = 336/8.50 – 336/7.90 = 3.00D; Air cylinder = +2.00D – (-1.00) = 3.00D

For a cylindrical power equivalent toric lens, the contact lens toricity is not equal to the air cylinder.

In Example 2, contact lens toricity = 336/8.00 – 336/7.55 = 2.50D; Air cylinder = -1.25 – (-2.75) = 1.50D

Note the difference between the two (1.00D) represents the magnitude of the residual astigmatism.