CHAPTER 10

FITTING SOFT CONTACT LENSES

This chapter deals with the basic techniques used to fit both soft and corneal RGP lenses

Although most contact lens practitioners fit disposable soft lenses, where the choice of lens parameters are limited to what the manufacturer produces, there has recently been a bit of a revival of the use of custom-made soft lenses. Some companies even specialise in this, solely making lenses outside of the standard range and/or bespoke lenses. Thanks to recent innovations, such custom soft contact lenses can now be manufactured in silicone hydrogel materials. It may therefore, be a good idea to revisit the fitting techniques used with soft contact lenses [122, 123].

In an average contact lens practice, a lot of time and energy is invested in acquiring new lens wearers. However, very little time is usually spent on current wearers. Perhaps, it's time to revive the lost art of fitting soft lenses which ensures optimal fit, comfort and health for our patients.

LENS PARAMETERS AFFECTING THE FIT OF SOFT LENSES

The most important lens parameters controlling the fit of a soft contact lens are the lens diameter, base curve and peripheral design of the lens [122–128].

- Diameter – increasing the total diameter will increase the sag of the lens and tighten the fit. Whereas, reducing it will have the opposite effect. Total diameter might also be increased to improve corneal coverage in a lens fitted onto a cornea with a displaced corneal apex. Changes to lens diameter impacts fit to a greater extent, than changes to the base curve
- Base curve (BC) – traditional soft contact lens fitting theory states that, as the BC increases, lenses move more and as it decreases, lenses move less. Most practitioners have experienced situations where changing BC has a minimal, if any, effect on the lens fit. Numerous researchers have shown BC has no predictive value on lens movement
- Peripheral lens design – the peripheral design of a lens, which is the relationship between the front and back peripheral curves, has a marked effect on lens fit. In addition to fitting characteristics, the peripheral design influences lens handling characteristics and comfort. The practitioner is generally unable to change these parameters, and indeed, very little has been published that demonstrates the value of making changes. In practical terms, practitioners should be aware that changing a lens from one design to another, with the same BC and total diameter, will not guarantee that the lens will fit in the same way
- Lens material - soft lens materials have a profound effect on fitting characteristics. A 38% percent HEMA lens responds differently compared to a 59% percent GMA lens. High water content lenses typically fit flatter, therefore, BC selection should be slightly steeper. Lens hydration controls how fast a lens stabilises and therefore affects chair time. Lens dehydration can change fitting strategies because a lens applied to the eye in the morning will act differently eight hours later. Other factors such as lens thickness, lens lubricity, lens modulus and tensile strength can all influence base curve selection

OCULAR PARAMETERS AFFECTING THE FIT OF SOFT LENSES

In terms of ocular parameters, corneal sagittal height is important as it defines the most appropriate contact lens-to-cornea fitting relationship. Other parameters include; position of the corneal apex, lid pressure and tear morphology. The curvature of the cornea has a relatively small influence on its sagittal height compared to eccentricity or shape factor and corneal diameter [126]. It is therefore a poor predictor of soft contact lens fit although it is still extensively used when selecting soft lenses. The corneal curvature and diameter is positively correlated, steeper corneas tend to be smaller in diameter and larger corneas tend to be smaller in diameter. A similar relationship exists between corneal diameter and sagittal height [88].

- Sagittal height – Sagittal height is affected by the central corneal radius, eccentricity or shape factor, corneal diameter, peripheral corneal slope and scleral radius. Generally, large steep corneas have larger sagittal depths and need steep soft lenses with larger sagittal depths. While small flat corneas have small sagittal depths and therefore, need flatter soft lenses with small sagittal depths [88, 126]
- Corneal apex – a displaced corneal apex will lead to a decentred lens. Increasing the total diameter of the lens will expand the corneal coverage. While changes in the BC will have little effect on centration [122]
- Lid pressure – tight lids often result in a high-riding lens and possibly excessive lens movement. Using a thin lens design and/or increasing lens diameter are management options. Loose lids generally have less effect on lens fits, although insufficient lens movement is a possible consequence [129]
- Tear morphology – both pH and osmotic pressure can change lens parameters and affect the fit of the lens. A reduction in pH leads to steepening of the ionic contact lens parameters. One study has shown that both ionic and non-ionic lenses tighten in fit as the tonicity of the tear film is reduced [130]. This is clinically significant because, if a satisfactory fit cannot be obtained with one contact lens material, then it might be worth changing the ionicity or water content to another material [130]
- Horizontal visible iris diameter (HVID) - The typical horizontal visible iris diameter HVID is approximately 11 mm to 12 mm. Therefore, most manufacturers offer standard 13.8 mm to 14.5 mm soft lens diameters. However, eyes that have a small HVID may need a smaller diameter or flatter base curve and eyes that have a large HVID may require a larger diameter or steeper base curve. Measuring corneal diameter is an art in itself. There is normally a difference between the horizontal and the vertical corneal diameters, the vertical being smaller compared to the horizontal. With-the-rule (WTR) and against-the-rule (ATR) astigmatism also affect the accuracy of the measurement. Additionally, the vertical diameter is difficult to measure, as the eyelids can be a physical barrier. It is common practice to use the oblique meridian as some sort of "average value." Measuring "white-to-white" at a 45-degree angle using a corneal topographer may be a good way of doing this, rather than using a ruler.

One way to improve soft contact lens selection and fit is to adjust the keratometry measurements based on the sagittal height influence of corneal diameter. Assuming that, the average HVID is 11.8 mm an adjustment can be made to the K-reading. For every 0.2 mm larger than 12.0 mm, you should add 1.00D to the flat K value in dioptres, resulting in a steeper lens. For every 0.2 mm smaller than 11.6 mm, you should subtract 1.00D from the flat K value, resulting in a flatter lens (Table 22). An additional adjustment to the soft lens base curve must be made because the corneal shape is elliptical. It is suggested that 0.3 mm should be added to the HVID adjusted BC to determine the BC of the soft contact lens

Corneal diameter plays a more significant role in the fit of a soft lens than BC. Therefore, if the fit needs to be changed because a lens is too tight or loose, the diameter should be changed before the BC to have a significant impact. In defence of using the radius, eyes that have flatter central K values more often also have larger corneal diameters. In that sense, there may be some indirect relationship between curvature and lens fit. Nonetheless, it would be better to look directly at the more influential parameter—corneal diameter [122, 123]

- Corneal eccentricity - Young et al., 2010 showed that for aspheric soft lenses, the eccentricity has a larger impact on total sag height than the central radius [124]. For example, a 0.12 change in eccentricity is believed to be equivalent to a 0.2 mm base curve radius change. In addition, diameter seems to play an even larger role. An increase in lens diameter from 14.0 mm to 15.0 mm in a contact lens that has an 8.3 mm base curve can add up to a 700- or 900-micron increase in sagittal height depending on whether the lens design is spherical, aspheric or multi-curve. The effect is slightly less for an 8.7 mm base curve radius because the total sag height of that lens is also less, but it still could increase the sag height by 600 microns to 750 microns. This has significant consequences when we fit toric soft lenses which are commonly 0.5 mm or larger than their spherical equivalents, resulting in a change of 500 or 600 microns, similar to the corneal thickness of ±540 microns.

  By comparison, if we change an 8.3 mm base curve to an 8.7 mm base curve while keeping the total diameter the same, the change in sagittal height would be in the order of 300 microns, which is much more limited. The lens becomes "flatter" although it would be better to refer to it as having less sagittal height. Perhaps, going forward we should refrain altogether from using terms such as "flatter" or "steeper" in soft contact lens fitting and rather transition into using terms such as "higher" and "lower" sagittal values to better convey what is happening on the ocular surface. In scleral lens fitting, these terms have become more universally used.

  If a cornea is larger than average and if the central K readings are steep and/or the eccentricity is low, it has a huge impact on the total sagittal height of that cornea and consequently on the soft contact lens of choice. Of course, the opposite is also true, smaller corneal diameters combined with flat curves and high eccentricities result in clinically significant lower sagittal values, for which the lens sag should be selected accordingly to achieve an optimal or acceptable contact lens fit. [124–126]
- Finally, soft lens overall diameter must exhibit proper corneal coverage and adequate movement so as not to compromise the limbus. A 1.5 mm scleral overlap on each side is sufficient to provide adequate coverage. Selection of an appropriate lens diameter ensures corneal coverage, good centration, lack of limbal compression, lack of edge standoff and sufficient lens movement (and tear circulation), which helps to ensure that the contact lens provides stable vision.[122, 123, 125]

In the past ± 3 mm of the central cornea was measured using a keratometer and a base curve (BC) for the soft lens was selected typically 0.8–1 mm flatter than the flattest corneal curve. Making contact lens choices based on measurements of such a small and central corneal area may be error prone. Given that the average soft contact lens measures 14.0 mm in diameter, the limitations of keratometry are obvious. However, despite the apparent over simplification of using keratometric measurements to define corneal shape, the majority of patients achieve a successful contact lens fit, but some patients just don't fit within this fitting paradigm.

Table 22: Base curve compensation according to corneal diameter [131]

Corneal Diameter	Base Curve Compensation, add to Flattest K
10.00 mm	-8.00D
10.20 mm	-7.00D
10.40 mm	-6.00D
10.60 mm	-5.00D
10.80 mm	-4.00D
11.00 mm	-3.00D
11.20 mm	-2.00D
11.40 mm	-1.00D
11.60 mm	0.00D
11.80 mm	0.00D
12.00 mm	0.00D
12.20 mm	+1.00D
12.40 mm	+2.00D
12.60 mm	+3.00D
12.80 mm	+4.00D
13.00 mm	+5.00D

DETERMINING LENS POWER AND THICKNESS

Lens power can be determined by taking a patient's spherical equivalent from his spectacle Rx and correcting for vertex distance. This can be done using appropriate vertex tables or mathematically using a formula. Traditionally, practitioners would convert the sphere and cylinder to cross-cylinder form and then convert this to the corneal plane using a 'vertex chart' before reconverting to a minus-cylinder prescription.

The optimal lens thickness should result in the least mass. An ideal lens design provides full corneal coverage while taking into consideration individual patient factors such as comfort, overall corneal oxygen requirements and patient dexterity. If lens manipulation or durability is a problem, use a thicker lens [1, 88, 89].

FITTING THE LENS [1, 88, 89]

Apply the lens and allow 10 minutes to 30 minutes, for lens dehydration, to assess proper fitting relationships. Some lenses dehydrate more than others. Lenses that retain water content don't bind and dry at the end of the day. These lenses can be evaluated soon after applying them. Soft lenses dehydrate *in vivo* and lose up to 20% of their water content over the course of the day. This is especially true with traditional hydrogel materials. Dehydration is slower in low-water content lenses than in high-water content lenses. Thus, a high-water-content lens reaches a steady state of hydration on the eye more rapidly than a lower-water-content lens. Water evaporates from the lens surface and as the hydrogel lens surface dries, more water diffuses from the bulk of the lens to its surface where evaporation continues. Water may also permeate from the tear film that separates the lens from the epithelium. Therefore, given two hydrogel lenses of equal thickness but different hydration, water diffusion from the bulk of the lens to its surface will be easier in the high-hydration lens, because the polymer network is looser and easier for the water to diffuse than in a tighter network lens. As a lens dehydrates, its base curve becomes steeper. High-water-content lenses dehydrate more than similar lenses of lower hydration under the same conditions. Therefore, high-water-content lenses have a greater tendency to tighten on the eye than lower-hydration lenses. During the course of the day, hydrogel lenses tend to “tighten up” during wear [70]. For this reason, manufacturers and educators suggest compensating for this by selecting traditional lenses that are around 0.7 mm flatter than the central cornea. Low-water-content silicone hydrogel materials and more water-retaining materials tighten up as well, but to a lesser extent [132]. In theory, this means that these contact lenses can be fitted somewhat steeper. These lenses can be selected to be only 0.4 mm flatter rather than the otherwise 0.7 mm for traditional hydrogels. However, with one exception, the base curves listed on silicone hydrogel contact lens packages typically have the same or very similar values as compared to traditional hydrogel lenses even though they could be fitted steeper [70].

Is the initial fit assessment of a contact lens really a reliable indicator of end of day fit and patient comfort? As mentioned, historically soft lenses were left to ‘settle’ for 20–30 minutes before an assessment of fit took place. In the 1990s, it was shown that the post blink movement of a hydrogel lens had a biphasic pattern, reducing to a minimum over the first 20–25 minutes after lens insertion, but then increasing again after eight hours of wear to a level similar to that seen at five minutes after insertion. This suggested that the most appropriate time to assess lens movement was approximately five minutes after insertion [133, 134].

Several theories as to why this reduction in lens movement occurs have been proposed. A common theory is that, as a lens dehydrates there is a steepening of the BC, the consequences of which are a reduction in lens movement [70]. However, lens dehydration does not appear to be correlated to post-blink movement in hydrogel lenses. The second theory is that, reflex tearing on lens insertion causes hypotonicity of the pre-lens tear film (PLTF), allowing water to flow through the lens towards the cornea, leading to lens adherence. As the reduction in lens movement appear similar in experienced wearers and neophytes, this seems unlikely. Reduction of lens movement is more likely to be due to a gradual thinning of the post-lens tear film (PoLTF) with blinking [129].

Recent research using modern lenses found a similar pattern in the reduction of lens movement from 5 minutes after insertion, more so with traditional hydrogel lenses than silicone hydrogel lenses. But, with no increase in movement after the 25-minute mark. There was an agreement that assessment of hydrogel lens fit after 5 minutes of wear can be predictive of the end of day fit (although not equivalent to end of day fit). However, silicone hydrogel lenses may take nearer 20 minutes to settle before fit can be reliably assessed, possibly due to their higher modulus.

The optimal lens has the flattest base curve that centres consistently and doesn’t move excessively with blinking or exaggerated eye movements. Remember, lenses may tighten over time, so if in doubt go with the flatter lens. A simple push-up test will verify lens movement and tightness [88]. The quality of the keratometer mires or retinoscopic reflex can also be helpful to ascertain the proper lens fitting relationships [88]. Determine visual acuity and over-refraction with the lens on the eye after total lens adaptation. Over-keratometry or retinoscopic reflex will help establish the optimal lens fit [1, 88]. A steep fit, results in clear but wobbly mires immediately after the blink that then becomes distorted and blurry. A flat fit, results in mire distortion that becomes more distorted on the blink. Visual acuity will sharpen momentarily after the blink, but then blur. Additionally, lenses that dehydrate more than expected will have a dull reflex and are associated with decreased visual quality, especially towards the late afternoon and evening [89].

THE EFFECT OF THE TEAR FILM ON SOFT CONTACT LENS FIT

The relationship between a soft contact lens and the pre-corneal tear film is important, firstly, because of the effect it has on the movement of the lens, and secondly, because of the importance of tear exchange beneath the lens, which is essential to maintaining healthy corneal physiology. When a soft contact lens is inserted onto the eye the pre-corneal tear film, which is approximately 3 μm thick, is split into two layers; a pre-lens tear film (PLTF), which covers the front surface of the lens, and a post-lens tear film (PoLTF) between the back surface of the lens and cornea [47]. Once the lens has settled on the eye the PLTF is thought to be approximately 2 μm thick, while the PoLTF is between 1–3 μm thick at the corneal apex [47]. Studies have shown that, during blinking a soft contact lens deforms under the pressure of the eyelid inducing a negative pressure in the PoLTF between blinks. This "squeeze" pressure is greater when the lens is thicker, of higher elastic modulus and steeper radius of curvature [129]. Thinner and higher water content lenses mold more closely to the shape of the cornea, resulting in a thinner PoLTF and do not rely on PoLTF 'squeeze pressure' in the same way. The movement of these lenses is more likely to be affected by the relationship between the lens and the lubrication properties of the pre- and post-lens tear films [130]. The PLTF reduces friction between the front surface of the lens and the eyelid, while the PoLTF reduces friction between the back surface of the lens and cornea. A thin PLTF could increase post blink lens movement due to an increase in friction. Whereas, an aqueous depleted PoLTF has been shown to be associated with a reduction in soft lens movement [130].

The studies investigating the effects of the tear layer on soft contact lens movement have done so in relation to hydrogel lens materials. As silicone hydrogel lenses tend to be of higher modulus/lower water content materials, the forces working on them *via* the tear layers may affect movement differently.

Tear exchange between the PLTF and PoLTF is essential to reduce the accumulation of debris between the contact lens and cornea. Tear mixing under a soft contact lens is estimated as 1.2%, which is much less than under an RGP lens (15–16%). Reducing the diameter of a hydrogel lens from 13.5 mm to 12 mm, increases tear exchange marginally (0.6%). There is limited information regarding the effect of lens movement on tear exchange or to suggest clinically how much movement is required to ensure adequate tear exchange.

EVALUATING LENS COMFORT [1, 88, 89, 131]

Patient comfort depends on lens edge awareness upon the lower lid. A simple clinical test to check this is to pull the lower lid down away from the eye and question the patient about the difference in lens edge awareness. Always check the peripheral lens design for material gaping or gathering as a reason for discomfort. Move the lens away from the lower lid edge by increasing overall diameter, which tucks the lower edge of the lens into the lid sulcus or fit the lens closer to the corneal surface, so the lid can roll over the lens to improve the comfort. Dryness symptoms have also been associated with both increased lens movement and inferior lens decentration. Decentred lenses are often associated with looser fits and it has been suggested that the dryness may be due to the decentred lens aggravating the upper eyelid margin, thereby exacerbating lid wiper epitheliopathy. This has important implications for lens fitting as it appears that the balance between providing enough lens movement to facilitate tear exchange and excess movement causing discomfort and possible patient drop out is a fine one.

It is important to remember though that lens discomfort can be caused by numerous factors such as lens material, solution sensitivity, dry eyes, environment and allergies, to name a few. A lens that shows a slightly loose fit is not necessarily the sole cause of discomfort. Knowledge about lens polymer interactions can solve many patient-related problems that result from the wearing environment. An example is a computer user who can't wait to get home after work to take out his lenses, although he/she seems to wear them comfortably on the weekends. Patients blink less frequently during computer use and the air quality in offices may be lower than that at home. Lenses tend to dry out more in such environments.

EYE SHAPE AND SOFT LENSES

The fitting of soft lenses unfortunately has become a bit of a lost art. Corneal deformations or warpage because of suboptimal soft lens fitting are not as uncommon as many may think. If practitioners would remove soft lenses at every follow-up visit and perform corneal topography, they would be surprised by the amount of unwanted changes that can take place beneath a soft lens. According to a study by Schornack et al., 2003 about one-third of all corneal warpage cases result from soft contact lenses [135]. Refractive surgeons have made it quite clear for some time that it is critically important to cease soft lens wear for a substantial period of time to let the cornea settle before laser surgery can take place. In fact, most unsuccessful refractive surgery outcomes that result in residual refractive error are caused by lens wearers who undergo the procedure before their corneas have had sufficient time to stabilise [136]. According to a study by Ng et al., 2007 it takes on average 10.7 ± 10.4 days before a stable refractive state is reached after cessation of soft lens wear. If we use the keratometry value as the criterion, then it takes an average of 16.2 ± 17.5 days for the cornea to become stable. Using corneal topography, it takes 28.1 ± 17.7 days. For the mentioned methods, a change of 0.5D or less between two examinations is used as the criterion. But if pachymetry (corneal thickness measurement) is used as a method, then it takes on average 35.1 ± 20.8 days before stability is reached in a soft lens wearer (with an 8 μm change at the thinnest point on the cornea as the criterion). The outcomes differ considerably between subjects and therefore it seems that in some patients it may take significantly longer compared to the average eye before the cornea is considered stable [137]. Wang et al., 2002 found a 12% incidence of significant contact lens-induced corneal warpage with contact lens wear. In patients demonstrating lens-associated warpage, the mean duration of prior contact lens wear was 21.2 years. Lens use included daily wear soft, extended-wear soft, toric and rigid gas-permeable contact lenses. Up to 3.0D refractive and 2.5D keratometric shifts accompanied by significant topography pattern differences were observed. The average recovery time for stabilisation of refraction, keratometry (change within ±0.5D) and topography pattern was 7.8 ± 6.7 weeks (range 1 to 20 weeks). Recovery rates differed between the lens types; soft extended-wear 11.6 ± 8.5 weeks, soft toric lens 5.5 ± 4.9 weeks, soft daily wear 2.5 ± 2.1 weeks and rigid gas-permeable 8.8 ± 6.8 weeks [136].

IDEAL FITTING CHARACTERISTICS OF A SOFT CONTACT LENS

The ideal fitting soft contact lens should give full corneal coverage and good centration. Movement needs to be adequate for good tear exchange, but not excessive reducing patient comfort, and vision should be clear and stable.

Table 23: Ideal fitting characteristics of a soft contact lens [134]

	Good fit	Tight fit	Loose fit
Total decentration (mm)	0.24 ± 0.23	0.32 ± 0.41	0.72 ± 0.58
Horizontal lag (mm)	1.21 ± 0.55	0.50 ± 0.54	1.75 ± 0.78
Post blink movement (mm)	0.25 ± 0.15	0.06 ± 0.06	0.40 ± 0.28
Tightness (mm)	47.8 ± 8.6	72.7 ± 12.3	35.6 ± 11.5

Young evaluated over 2000 hydrogel lens fits, subjectively classifying the lens as ‘tight’, ‘good’ or ‘loose’. The mean values for the characteristics assessed are shown in (Table 23). Lens tightness (ease with which lens could be displaced on push up) was found to be the best predictor of both loose and tight lens fits. An overall decentration of more than 0.3 mm was more predictive of a loose-fitting lens, while post-blink movement in primary gaze of less than 0.15 mm was found to be a sensitive indicator of a tight lens. Horizontal lag had little predictive value [134].

More recently Wolffsohn and Hunt, 2009 addressed the same question but in a slightly different way, by looking at which fitting characteristics measured objectively, contributed most to the overall movement of the lens in both traditional hydrogel and silicone hydrogel lenses. Horizontal lag, movement on blink in up gaze and push up recovery speed were found to account for just over 90% of the variance of the movement. A recommendation was made for a simple method of recording soft lens movement which includes a record of centration along with the movement characteristics discussed above, grouped into three categories (Table 24). Using this classification, a post blink movement of 0.4 mm would be represented as B- and horizontal lag of 0.25 mm as L0, on the traditional fitting diagram [133].

Table 24: Method to record soft lens movement [133]

	Large or fast (+)	Medium (0)	Minimum or slow (-)
Horizontal lag (L) (mm)	>0.5	0.25–0.5	<0.25
Post blink in up gaze (B) (mm)	>1.0	0.5–1.0	<0.5
Push up recovery speed (P) (mm/s)	>4	2–4	<2

OBJECTIVE AND SUBJECTIVE FINDINGS WITH GOOD, STEEP AND LOOSE FITTING SOFT CONTACT LENSES

Table 25: Objective and subjective findings of soft lens fitting [1, 88, 89, 128]

Characteristic	Good fit	Steep or tight fit	Flat or loose fit
Comfort	Good	Initially good	Poor
Centration	Good, complete corneal coverage	Usually good but may be decentred	Poor
Movement of blink	Up to 0.50 mm	< 0.25 mm	>1.0 mm
Movement on up gaze	Up to 1.0 mm	Little or none	>2.0 mm
Movement on lateral gaze	Up to 1.0 mm	Little or none	>2.0 mm
Vision	Good	Poor and variable, momentarily improves with blink	Variable and may improve when staring after blinking
Over-refraction	Precise end-point, correlates with spectacle refraction after vertex correction	Poorly defined end-point, more minus than expected due to positive tear lens	Variable, more plus than expected due to negative tear lens
Retinoscopy reflex	Clear reflex, before and after blinking	Poor and distorted with a central shadow which momentarily improves with blink	Variable may be centrally clear with peripheral distortion
Slit lamp observation	No limbal injection or scleral indentation	Conjunctival or limbal injection as well as scleral indentation	Localised limbal injection, possible edge standoff or fluting
Keratometer mires	Sharp, stable before and after blinking	Irregular with momentarily improvement after blinking	Variable and eccentric, changing on blinking
Topography	Regular image	Irregular image	Irregular image, often more in the periphery

RULES OF THUMB WITH REGARD TO SOFT LENS FITTING [88]

To improve a loose-fitting lens:

- Select a larger diameter lens
- Select a steeper base curve
- Use a more rigid or lower water content material
- Use a different lens thickness

To improve a tight-fitting lens:

- Select a smaller diameter lens
- Select a flatter base curve
- Use a less rigid or higher water content material
- Use a different lens thickness

Remember that a change in diameter of 0.50 mm ≈ a change in base curve of 0.20 mm

RIGID GAS PERMEABLE CORNEAL LENS FITTING

RGP lenses provide excellent visual acuity, particularly for regular or irregular corneal astigmatism and for patients who possess high amounts of refractive error. A complete history of any previous contact lens experience (albeit positive or negative) is essential to provide the clinician with the relevant information to discuss the lens choices available. Additionally, the patient's general health as well as ocular health must be considered before embarking on fitting RGP lenses. Auburn hair and freckled skin can indicate an increased corneal sensitivity which may hinder adapting to RGP lenses (see chapter 2). Establish patient motivation and their expectations. Patients with poor motivation may not possess the required determination to succeed with RGP lenses and may be non-compliant in the care of their lenses. Determine the patient's aspiration regarding wearing times, bearing in mind that part-time or 'social' wearers do not make ideal RGP patients. Consider the patient's sporting and physical activity requirements when using their lenses, along with specific occupational requirements. Explanation at the initial consultation should be given to the anticipated costs involved for the lenses and their maintenance. It would also be prudent to inform the patient what consultations are likely to be required in order to satisfactorily complete the contact lens fitting.

Patient Examination and Initial Measurements

Horizontal Visible Iris Diameter (HVID)

HVID should ideally be taken using a corneal topographer or slit lamp with an eyepiece graticule or adjustable slit height along the 45º meridian as discussed previously. However, in reality a ruler or adapted ruler is commonly used. This measurement provides an initial indication as to what the overall (total) diameter of the RGP lens will be. Most textbooks suggest that the lens total diameter should be approximately 1.5–2.0 mm less than the HVID.

Visible Palpebral Aperture (VPA)

VPA may also influence the choice of diameter of the contact lens. However, the actual value of the VPA is questionable. Greater relevance would generally be given to the position of the lids with respect to the limbus. The position of the upper lid can influence the degree of lid attachment, while the lower lid, if significantly low, may encourage the lens to decentre inferiorly.

Pupil Diameter/Size

Pupil size is measured in both normal ambient light and in reduced illumination using a Burton lamp or slit lamp. This measurement should be used as a guide to ensure the optic zone diameter (OZD) is greater than the largest pupil diameter. Generally, this approach will minimise symptoms associated with glare.

Corneal Curvature

Keratometers are used in practice to provide 'K' readings, measuring the curvature of the central cornea over a diameter of approximately 3–6 mm to determine the radii of curvature and the directions of the principal meridians.

In turn, this valuable measurement provides the practitioner with an indication of the BC of the lens. Keratometry will also reveal the amount of corneal astigmatism and any corneal distortion present. Corneal topography gives a more accurate measurement of the corneal curvature and astigmatism, often highlighting details not measured by keratometry which may affect the fit of the lenses.

Corneal Astigmatism

The keratometer readings, together with the refraction will guide the practitioner to the nature of the astigmatism. An assumption that can be made here is that:

Total ocular astigmatism = corneal astigmatism + lenticular astigmatism.

Broadly speaking, there are four sub- categories when comparing ocular refraction to the 'K' readings, namely:

- Spherical cornea with a spherical refraction
- Spherical cornea with an astigmatic refraction
- Toric cornea with an astigmatic refraction
- Toric cornea with a spherical refraction.

Spherical RGP lenses will only correct corneal astigmatism and will have no effect on the correction of lenticular astigmatism.

PRINCIPLES OF RGP LENS FITTING

Fitting sets are usually supplied for different RGP lens designs with fixed parameters such as diameter, number of curves peripheral curves and usually a variable parameter such as the BC. Generally, practitioners only have to deliberate about the design, BC and back vertex power (BVP) when selecting an initial trial or diagnostic lens from a fitting set.

One of the major benefits of fitting RGP contact lenses is the superior level of vision that patients will derive from them. This immediate superiority will often be undermined if practitioners are using diagnostic lenses, where the BVP of the lens is unlikely to match the patient's refraction. Fitting RGP lenses empirically allows the patient to experience first-hand this enhanced visual quality. Fitting lenses that are as close as possible to the patient's prescription will also minimise changes in the fit from variation in power. If using diagnostic lenses, it is important that myopes are fitted with a minus correction and vice versa for hyperopes, in order to evaluate the lens performance on the eye appropriately. The centre of gravity and edge profile of a plus powered lens is very different from that of a lens for myopic correction.

The BC of the initial spherical trial lens should be chosen using the K readings obtained, using either guidance from manufacturer's literature or using the principle illustrated in the following table.

Table 26: Base curve selection according to corneal astigmatism

Amount of Corneal Astigmatism	Contact Lens Base Curve
Spherical	On K or 0.25D (0.05 mm) < K
0.25 to 1.00D	On K or 0.25D (0.05 mm) > K
1.00 to 2.00D	0.50D (0.1 mm) > K
>2.00D	K + ΔK/3 or 1/3 steeper than K
>2.50	K + ΔK/3 or 1/3 steeper than K in Asticon or Toric Secondary Curve Design
>3.50D	Toric Base Curve or Bitoric Lenses

ASSESSING THE LENS FIT

Similar to fitting soft contact lenses, the assessment of RGP lenses involves evaluating both the static, how the back surface of the lens aligns to the cornea, and dynamic, how the lens centres and moves on the eye, fitting criteria. Once initial reflex tearing has subsided, usually within 5–15 minutes after insertion, assessment of the static fit can be made using fluorescein. Although the Burton lamp may be used to assess the fitting of an RGP lens, the slit lamp using both white and cobalt blue light, will provide the practitioner with a more thorough means of assessment. The contrast of the fluorescein pattern can be improved further with the use of a yellow barrier filter (Wratten filter).

Aligned Fitting Characteristics

- Good lens centration. The lens should be centred over the pupil in primary gaze and centration should remain adequate with each blink. This will help to ensure that the visual axis remains within the OZD of the lens and minimise flare
- The lens should remain on the cornea during all positions of gaze
- Visual acuity should be crisp and stable
- Alignment type fluorescein pattern show alignment or slight apical clearance over the central region, mid peripheral touch and a narrow band of edge clearance of approximately 0.50 mm in width. Typically, the fluorescein pattern centrally should be similar to the pattern just outside the edge of the lens over the cornea. This indicates an optimal fitting relationship with no bearing on the cornea
- With a normal lid position, the edge of the lens should not overlap the limbus. The ideal position of the lens is when the edge of the lens is near the superior border of the limbus and is covered by the upper lid during blinking
- 1–1.5 mm of vertical smooth movement with each blink. This is one of the main characteristics of a well-fitted RGP lens. This movement facilitates tear exchange, allowing metabolic and tear debris to be removed from under the lens, along with oxygen exchange during the blink cycle due to the tear pump action
- When the lids are held apart, the lens should slowly decentre downwards
- Reasonable initial comfort, which continually improves during adaptation

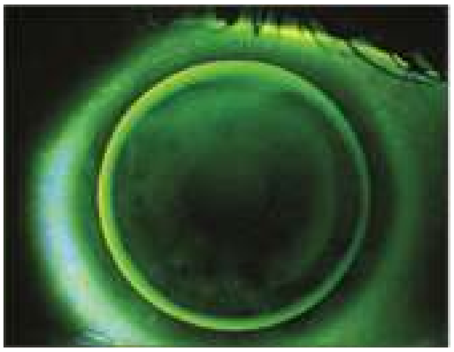

Figure 36: Corneal RGP fitted in alignment with the corneal curvature

Flat Fitting Characteristics

- A central darker area of apical touch (due to the absence of fluorescein)
- Very broad green edge band of lens clearance
- Excessive movement on blinking (be aware of excessive initial tear lacrimation which may be misinterpreted)
- Possible conjunctival staining

- Patients often complain that comfort is poor, and adaption is severely compromised
- Excessive tearing even after adaptation
- Inconsistent vision
- A negative tear lens is formed, leading to a 'plus powered' over refraction

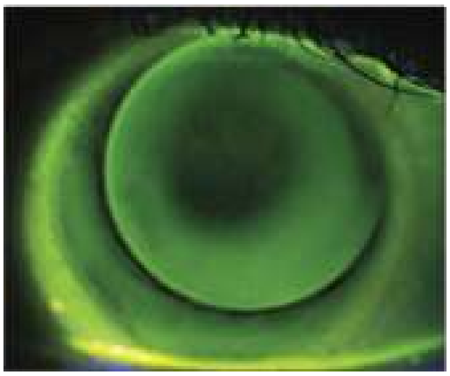

Figure 37: Flat fitting RGP corneal lens

Steep Fitting Characteristics

- Appearance of excessive central green 'pooling' beneath the lens, which may also include trapped air bubbles under the lens. A darker excessive touch in the mid peripheral region
- Minimal lens edge clearance
- Movement is static and sluggish. Insufficient lens movement will hinder an adequate tear exchange, this stagnation of the tears leads to corneal staining and distortion
- Possible corneal epithelial indentation caused by the edge of the lens
- Minimal lid sensation reported by the patient
- A positive tear lens will be formed beneath the lens, which will create a 'minus powered' over refraction

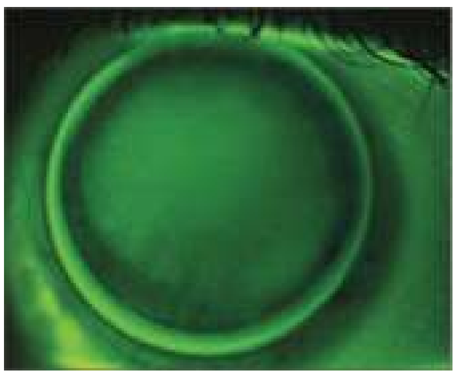

Figure 38: Steep fitting RGP corneal lens

Most modern RGP system lenses are designed to facilitate ease of fit. This will generally offer practitioners reassurance providing they follow the guidelines provided by the manufacturer. Most lenses fitted will invariably provide an optimal result. However, situations might occur when the first diagnostic lens does not generate the expected result. The following rules of thumb can be helpful to navigate through the options to rectify the fit.

Decentration

Excessive decentration in any direction is indicative of a flat fitting lens, where a steeper fit would be appropriate. Excessive corneal astigmatism may also be a factor, where fitting a back surface toric would remedy this. A completely stationary lens is fitted too steep and a flatter design would be required. Where horizontal decentration occurs, caused by the eyelids, then a smaller diameter lens should be used. If the lids are not the cause, then either fit a lens with a larger diameter or steepen the BC. Against-the-rule astigmatism may also be responsible. Here, spherical lenses will not work and a back surface toric should be considered.

With continually low decentration, the lens may be too thick, particularly in higher prescriptions. Also consider that the overall diameter of the lens is too small, this is especially relevant if there appears to be no lid interaction.

If you observe continually high decentration, again the thickness of the lens may have to be evaluated and if necessary, reduce the lens thickness. The diameter of the lens may be too big or excessive amounts of with-the-rule astigmatism may be to blame. This could only be properly remedied with a back surface toric RGP.

Increased Movement

To increase movement of an RGP lens:

- Increase BC
- Decrease OZD
- Decrease total diameter

Decreased Movement

To decrease movement of an RGP lens:

- Decrease BC
- Increase OZD
- Increase total diameter

Basic Rules of Thumb for Alterations to Maintain Fitting Relationship OZD and BC

- An increase in OZD of 0.5 mm will require a flattening of the BC by 0.05 mm
- A decrease in OZD of 0.5 mm will require a steepening of the BC by 0.05 mm

Toric Base Curve Lens Formula

- The base curve is selected as follows: Flat meridian on K or slightly steeper 0.25D (0.05 mm) than K. The steeper meridian is fitted K + ΔK/3 or 1/3 steeper than K. This will improve the fitting relationship between the cornea and the lens and take care of the corneal astigmatism

Vertex and Residual Astigmatism Formula

- $F_c = F_s/1 - dF_s$
- $A_1 = A_c + A_r$
- ***Legend***
- ***K = Flattest corneal radius, ΔK = Difference between principal central corneal radius or curves***
- ***F_c = Contact lens Power, F_s = Spectacle Power, d = vertex distance in meters***
- ***A_1 = Total astigmatism, A_c = Corneal astigmatism, A_r = Residual astigmatism***

BC AND BVP

- An increase in BC of 0.05 mm will require 0.25D less minus prescription
- A decrease in BC of 0.05 mm will require 0.25D more minus prescription
- Or every 0.1 mm change in base curve = 0.50D change in lens power

Finally, increasing the diameter will generally aid comfort, while decreasing the diameter will have the opposite effect.

TABLES OF SUBJECTIVE AND OBJECTIVE FINDINGS WITH RGP CORNEAL LENSES, THEIR PROBABLE CAUSES AND CORRECTION

Table 27: Subjective findings, causes and remedies when fitting RGP corneal lenses

Subjective Findings	Probable Cause	Correction
Fluctuating Blur	Excessive lacrimation (early stages normal)	Check lens movement Check lens position Check for flexing
Distortion	Tilting of lens (too small or flat)	Make larger or steeper lens
Ring Flare	Optic zone in pupil area	Increase optic zone size and/or lens size
Reduced Acuity - initial	Residual astigmatism Improper lens power	Refract through contact lens Check for flexing
Reduced acuity - late	Warped lens Switched lenses	Check base curve, power and for warpage
Hazing, Halos, Fogging	Inadequate exchange of tears Dirty lens	Reduced optic zone Reduced lens size Clean lenses
Reading blur	Overpowered minus Poor centration	Over refract Correct centration
Pain after removal	Corneal edema Lens too tight	Reduce optic zone Flatten base curve Reduce lens size
Sudden pain	Foreign body Chipped lens	Check eye Check lens edge
Burning (hotness)	Tight lens Corneal periphery flat Chemical on lens	Re-blend periphery Flatten lens Cleanse lens well
Cutting pain	Chipped or tight lens Foreign body behind lens	Inspect edge carefully Cleanse lens
Ache (deep)	Tight lens	Remove lens a few days Recheck K Loosen lens
Itching	Possible allergy to solution Dirty lenses	Change solutions. Different preservatives Clean lenses
Excessive lacrimation	Normal in adaptation Rough edge Improper fit	Refit the contact lens carefully Check edge
Lid Edema	Lagging lens Bad or rough edge	Check lens edges Refit lenses to improve position
Difficulty in looking up	Improper edge Lens too small	Check lens edge Increase lens size
Photophobia	Tight lens Lens too flat Foreign body stain	Refit lenses Clean lenses
Fogging (late)	Tight lens Dirty lens	Reduce optic zone Flatter base curve Clean lenses

Table 28: Objective findings, causes and remedies when fitting RGP corneal lenses

Objective findings	Probable cause	Correction
Excessive movement	Lens too loose Lens too steep Excessive tearing	Check fluorescein pattern Check lens edge
No movement	Lens too large and/or steep	Flatten base curve Reduce lens size
Displacement by lid	Edges too thick Lens too large or flat	Reduce edge thickness Reduce lens size Steepen base curve
Bubbles under lens	Lens too steep and/or large	Flatten base curve
Central pool with ring touch inside bevel	Base curve too steep	Flatten base curve
Central touch	Lens too flat	Steepen lens
Excessive edge standoff	Peripheral curve too flat or wide	Make new lens with narrower and/or steeper peripheral curve
"H" Pattern	Excessive corneal astigmatism	Inside toric curve if necessary
Fine Stipple	Normal in adaptation Insufficient circulation	Flatten base curve Reduce optic zone Clean lenses
Zig-Zag Corneal Stain	Foreign body under lens	Clean the lens
Stain / 3 and 9 o'clock position	Too flat periphery Improper size	Steepen secondary curve Flatten base curve Alter size 0.4 mm
Deep Corneal stain with pain	Corneal ulcer with possible uveitis	Stop wearing lens Institute medical care
Unusual change in refraction	Lens too flat or steep	Compare K with original reading. Refit after 5–6 days without wearing lens
Mucus on lens	Scratches on lens surface. Deposits on lens	Polish lens surfaces Use enzymes
Lens falls out	Too small or too flat	Larger lens or tighter lens
Lens rides to side	Against the rule astigmatism	Steepen lens and reduce optic zone Make toric base
Lens rides under upper lid	Too flat anterior curve pulled up by lid Lens too flat	Reduce lens size Steepen base curve Order lenticular
Lens rides too low	Lens too small Lens too thick Lens too flat	Reduce thickness (weight) Steepen lens Use lenticular