Contact Lenses in Management of Irregular Cornea

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Advances in lathing technology and corneal topography have expanded the indications for contact lens fitting in patients with irregular cornea such as keratoconus with sagging oval or globus cones, Kearatoglobus, pellucid marginal degeneration, post keratoplasty and post traumatic corneas. Analysis of topography maps reveals that many corneal ectasias are inferior, rather than central, making fitting more challenging. Patients with pellucid marginal degeneration; large, sagging, oval cones; or Kearatoglobus may require large, limbus-to-limbus lens designs. Even these, however, may exhibit inferior edge standoff, causing discomfort and even lens displacement as the lens interacts with the lower lid during the blink cycle. Lathing technology now enables fitters to request quadrant specific lens designs to accommodate the corneal asymmetry that occurs frequently in the inferior portion of the cornea.

Many laboratories are not only able to produce lenses that are steeper inferiorly, but can actually vary the base curve radii in any or all of the four quadrants. The edge lift can also be made several steps flatter or steeper than the standard edge lift in any or all of the four quadrants. When necessary, the base curve and peripheral curve designs can be combined. (Table 1) shows various contact lenses available for irregular cornea.

To fit contact lenses is a challenge in patients with irregular cornea. Aim of this article is to simplify the selection of a right contact lens to obtain an acceptable fit with improved vision in such patients.

Prerequisite for the Fitting

Keratometry and corneal topography are important tools and a guide in selecting the parameter for the initial trial lens indices. A trial lens (diagnostic) approach is necessary to achieve an acceptable contact lens fit. Fitting of contact lens in patients with irregular cornea is complex, necessitating longer chair time and multiple diagnostic fitting trials. Most keratometers are in the range of 36 to 52 D and the range of keratometry measurement can be increased with a spherical lens of +1.25 in front of the central aperture of keratometer mire to 61 D. This helps in measuring the curvature in cases of advanced disease. Corneal topography helps in assessing the severity and in knowing the morphology of the ectasia i.e., nipple cone (small, paracentral, steeper, located inferiorly or inferonasally), oval cone (inferiorly or inferotemporally steeper cornea) and globus cone (overall steeper cornea). The globus cone is much larger and involves more than three fourth of the cornea up to the limbus.

Corneal Gas-Permeable (GP) Lenses

Corneal gas-permeable (GP) lenses range in size from 8.0 to 10.0 mm in diameter. Diameter, base curve and power of the contact lens are important criteria in selecting the first lens. A multitude of lens designs including reverse geometry exists. Each lens can be specially made with custom parameters. Fitting sets are available such as the Collaborative Longitudinal Evaluation of Keratoconus diagnostic set or Rose K fitting sets from different contact lens laboratories with aspheric base curves.

Fitting goals for a corneal GP lens are to vault minimally over the corneal apex to prevent epithelial disruption, provide midperipheral bearing, and moderate peripheral clearance. An ideal fit is easier to achieve in early keratoconus; however, in more advanced cases, it may be difficult to obtain an “optimal” fit because of the corneal irregularities. The types of contact lens fitting include apical
clearance, apical bearing or three point touch; the three point touch being the most widely accepted one.

**Apical clearance**

There is no bearing or touch in the apical area i.e. vault is present the apical area is clear. The lens bearing is directed towards the periphery. This reduces the risk of scarring, whorl keratopathy and erosions. Tightening at the periphery may result in sealing of tear exchange.

**Apical bearing**

The optic zone of the contact lens touches or bears on the apex of the cone resulting in good visual acuity. Because of the flatter fitting of the lens on the cornea, there can be heavy bearing on the cornea. This can result in corneal scarring and intolerance over long term use. The quality of vision is better with apical bearing.

**Three point touch or divided support**

Lens bearing is shared between the apex and the midperipheral cornea. This helps in minimizing the risk of apical scarring as well as facilitates the tear exchange. This is the most preferred type of lens fitting. It provides good vision, better comfort and prolonged wearing time (Figure1).

After allowing for an adaptation period of 30 min for the
Contact Lens

Contact lens on the eye after insertion, both the dynamic and static fit should be assessed. In dynamic fit, the lens fit is considered to be acceptable when the lens is centered on the cornea adequately during post blink movements, good stability in different gazes and the patient is comfortable during all these movements. The movement should be not more than 1mm with every blink and the lens should not cross the limbus. The static fit is assessed after instilling fluorescein in the eye with cobalt blue filter with or without the Wratten filter. (One can use the yellow gelatine paper if Wratten filter is not available for fitting assessment).

The trial should be repeated until an acceptable dynamic and static fit is achieved. An ideal fit will show a central feather touch, a peripheral edge lift of 0.5-0.7 mm. But, as the cone advances, the lens edge may stand off with pooling and air bubbles under the peripheral edge. These peripheral edges can be steepened in meridians according to the area of clearance and edge lift sectorally as per company guidelines.

Advantage of corneal GP lenses is that they provide a smooth regular surface that masks the underlying corneal irregularity and improves quality of vision. They also provide good tear exchange.

Disadvantages are stability (more likely to decenter) and difficulty for patient adaptation. If GP intolerance is an issue and the patient has poor comfort with the lens, then another lens option is indicated.

There are various materials and designs available for fitting these lenses such as traditional or customized lenses that are made locally (e.g., Material Flouroperm 90, CLASSIC company, Bangalore, India), or Rose k lenses (Menicon Z material from Menicon Co., Ltd, Nagoya, Japan). Materials with high oxygen transmissibility should be selected to prevent hypoxia related corneal changes.

Rose K lenses

These lenses are multicurve lenses with a small optical zone which snugly fits the cone, for the so called ‘feather touch’ to the cornea. When the cone is a central nipple cone, a Rose K lens (Menicon Co., Ltd, Nagoya, Japan) can be selected (Figure 2a,b). As per company recommendation the selection of first trial lenses to be 0.2 mm steeper than the average K for mild to moderate K values (average k reading is flatter than 6.00 mm). For advanced (average k values are between 5.1-6.00 mm) the first lens to be applied should be same as average k value and 0.3 mm flatter than the average k in severe cases (average k values are steeper than 5.00 mm). Once the optimal lens fit is achieved, the final power should be calculated after performing a spherical over refraction over the trial lens.

Rose K2 Lens

Rose K lens was further refined to take into account the unusual corneal shapes of keratoconus patients, which require abnormal curves on the back of the lens to fit the cornea optimally. This new lens is known as the Rose K2 lens.

Figure 2 (a,b): demonstrates the benefits of a smaller optical zone to fit the cone contour of a Rose K lens (b) compared to standard GP lens (a).
The Rose K2 lens minimizes aberrations by applying very small changes to the curves on both the front and back of the lens in an attempt to bring the light passing through the lens within the pupil zone to a single point.

Following extensive trials, the best combination of aberration control curves have been developed for computerized digital lathes to cut these very complex curves for the Rose K2 lens to give the best focus.

**Intralimbal Lenses**

Intralimbal lenses are slightly smaller than the cornea (10.5–12 mm diameter). The adult cornea has an average horizontal diameter of 11.5 to 12.6 mm and an average vertical diameter of 10.5 to 11.7 mm. The increased diameter of intralimbal lenses makes them a good alternative for fitting moderate amounts of keratoconus. Their relatively larger size allows for more corneal coverage, which improves centration; however, it may make application and removal more difficult. Some examples of Intralimbal lenses are DynaZ Intralimbal 11.2 mm (Lens Dynamics), KBA 10.2 mm (Precision Technology Services), Rose K2 IC 11.2 mm (Blanchard CL), Kone 10.4 mm (Medlens and Valley Contax), GBL 11.2 mm (ABB-Concise), and XL-T 11.0 to 12.0 mm (Medlens Innovations). The I Kone lens has a bisurface aspheric design and may be used when other GP lenses do not center or cause bearing on the central cornea. The posterior surface has 4 conic zones; the central portion vaults the cornea. The first and second zones distribute pressure over a larger area to manage corneal ectasia. The peripheral curve system is composed of the third and fourth zones that provide an alignment fit over the nonectatic area of the cornea. The aspheric anterior surface aims to reduce spherical aberrations. The standard I Kone diameter is 9.6 mm; however, the lens is also available in 8.8 and 10.4 mm. Intralimbal lenses fit with a central corneal vault or light feather touch with midperipheral bearing and moderate peripheral clearance. These lenses do not move as much as traditional GP lenses but should provide adequate tear exchange.

**Scleral Lenses**

The classification of GP scleral lens designed by Dr. Rob Breece based on bearing and clearance relative to the average corneal diameter (12.8 mm). These are of following types.

a. Corneoscleral lenses have corneal bearing and scleral touch (12.9–13.5 mm).

b. Semiscleral lenses have corneal and scleral bearing (13.6–14.9 mm).

c. Miniscleral lenses have scleral bearing and minimal corneal clearance (15.0–18.0 mm).

d. Full scleral lenses have scleral bearing and maximal corneal clearance (18.1–24.0 mm).

With normal corneas the shape does not change dramatically from the center out, but tends to change evenly in predictable amounts, and therefore with normal corneas the back surface of the lens can be designed with small incremental changes (e.g. eccentricity) over most of the lens with a peripheral curve at the edge. Usually, this will achieve reasonable alignment with the cornea and a good fit.
**Indications**

- Advanced Keratoconus particularly in decentered cones
- Pellucid Marginal Degeneration.
- Post Corneal Rings Implantation
- Keratoglobus
- Corneal Injury
- Radial Keratotomy (RK)
- Post Keratoplasty
- Ectasia post any corneal surgery
- As a substitute for Piggybacking
- Significant corneal irregularity
- Severe Dry Eye.

Contraindications for scleral lenses are corneas with significant edema from reduced endothelial cell count.

Corneoscleral lenses (12.9–13.5 mm) distribute bearing on both the cornea and the sclera. These lenses are used for decentered irregular astigmatism, pellucid marginal degeneration, and oval or globus cones. Corneoscleral lenses are not indicated for focal steep cones or if the corneal epithelium cannot tolerate bearing because the lens puts some pressure on the cornea. Examples of corneoscleral lenses are Semi-Scleral 13.5 mm (Abba) and SoClear Lens (13.5–15.0 mm; Dakota Sciences/Art Optical). The SoClear lens should equally distribute bearing along the corneal and scleral surfaces. The central and peripheral portions of the lens may be independently adjusted. An ideal fit for the Jupiter Lens (Essilor Contact Lens Division, Dallas, TX) is a light fluorescein layer (10–20 mm) of clearance over the entire cornea. More limbal clearance should be present with a brighter fluorescein pattern and scleral alignment with the edge above the scleral epithelium. SoClear contact lenses should equally distribute pressure along the corneal and scleral surfaces. The central and peripheral portions of the lens may be independently adjusted. SoClear lenses should have a light feather touch at the central cornea and moderate midperipheral clearance with an even amount of scleral bearing (Figure 3a,b,c).

Semi-scleral lenses (13.6–14.9 mm) provide both corneal and scleral bearing. Some examples of these lenses are Jupiter Lens (13.5–16.6 mm) and So2Clear (14.0 mm; Art Optical), Rose K2 XL semi scleral contact lens (Menicon Co. Ltd., Nagoya, Japan). Rose K2 XL semi scleral contact lens is shown to improve visual acuity and comfort and can avoid the need for PBCL in the management of the irregular cornea. Mini-scleral lenses (15.0–18.0 mm) have scleral bearing and minimal corneal clearance. Examples of these lenses are MSD (15.8 mm; Blanchard), Maxim (16.0 mm; Acculens), Jupiter (15.0–18.0 mm; Medlens Innovations/Essilor), Boston.

MiniScleral (15.0–15.5 mm; Foundation for Sight), and TruScleral (16.0–20.0 mm; Tru-Form optics). The ideal fit for the MSD (15.8 mm) lens is a central optic zone with apical clearance or feather touch and a midperipheral limbal zone that vaults the limbus and aligns with the sclera. The posterior surface incorporates reverse geometry, and the sagittal depth is adjusted independently of the central optic zone profile. Sagittal depth is the measurement from the flat plane to the highest point of a concave surface. If the sagittal depth is too high, then it leads to central bubbles. If the sagittal depth is too low, then it leads to excessive central touch and bubbles in the sclera. If there is excessive midperipheral clearance, then this leads to bubbles in the midperipheral and limbal zones. With the MSD lens, for each sagittal depth value, there is the option of 3 midperipheral/limbal clearance values. These are called standard, increased, and decreased, and each value can be adjusted for each lens.

Full scleral lenses range from 18.1 to 24.0 mm and have scleral bearing and maximum corneal clearance. Scleral lenses were used in the late 1800s and early 1900s and have now been reintroduced. The manufacturing process for scleral lenses has been improved, and larger lens diameters can now be accurately reproduced. Modern scleral lenses were developed by Perry Rosenthal and Don Ezekiel. The Jupiter scleral lens (Medlens Innovations/Essilor) ranges from 18.2 to 24.0mm in diameter. It is a semi-sealed lens that does not need to closely align with the cornea. The ideal fit of a scleral lens is to completely vault the cornea and limbus and to rest on the sclera. The lens has 3 zones: the corneal zone that includes the central corneal curve and the aspheric peripheral corneal curve, the limbal zone, and the scleral zone, which is made up of the aspheric scleral curve and the aspheric edge curve. The lenses are fit on the principle of sagittal depth, which is the measurement from the flat plane to the highest point of a concave surface. If the sagittal depth is too high, then it leads to central bubbles. If the sagittal depth is too low, then it leads to excessive central touch and bubbles in the sclera. The Jupiter scleral lens was proven to provide acceptable visual acuity and comfort in patients with keratoconus. The Tru-Scleral Lens (Tru-Form Optics) ranges from 16.0 to 20.0 mm in diameter, with a standard size of 18.0 mm. For patients with keratoconus, the lens should vault the cornea and rest on the sclera. These lenses are vented by 9 radial canals from 12 to 17 mm in diameter.

Advantages of scleral lenses include the ability to completely clear the corneal surface, provide good centration, and stabilize visual acuity.

Disadvantages include worse tear exchange and increased difficulty with respect to application and removal.
Piggyback Lenses
Piggyback lens fitting involves fitting a soft lens underneath a corneal GP lens\textsuperscript{11,12}. This modality is usually indicated if there is poor comfort or significant epithelial disruption with GP lenses, apical epithelial nodules, or accompanying epithelial basement membrane dystrophy. Improved GP and soft lens materials provide better oxygen permeability and prevent corneal edema and hypoxia. The base curve of the soft lens can be modified to alter the fitting relationship of the GP lens. A plus-powered soft lens is used to flatten the GP fit, and a minus-powered soft lens is used to steepen the GP fit.

Piggyback lenses may provide better comfort and, the same or better visual acuity than GP lenses, fewer corneal complications, less hypoxia, and the same or increased wearing time versus GP lenses worn alone.

Disadvantages
Include more difficulty and inconvenience with the piggyback lens system, loss of the GP lens, damage to the soft lens, and the need for multiple lens care systems.

The Flexlens Piggyback Lens (X-Cel Contacts) has an anterior surface central circular depression that recesses the GP contact lens within the soft lens. The lens is designed so that the GP lens stays within the soft lens carrier to decrease awareness of the GP lens. The GP lens acquires good centration and stability, which maintains GP optics over the pupil. The Flexlens Piggyback Lens is available in a wide range of base curves, diameters, and anterior cutout diameters.

Hybrid Contact Lenses
Hybrid contact lenses have a GP center and a soft skirt. More recent hybrid lenses are the SynergEyes lens\textsuperscript{13}. The SynergEyes A lens design is used for patients with early or moderate keratoconus (in addition to standard corneas). The SynergEyes KC lens design is used in more advanced keratoconus. A hybrid lens is a preferred lens if there is poor centration or poor stability with GP lenses. Reduced wearing time and lens intolerance are other indications for SynergEyes lenses. Both the central base curve and skirt curvature of SynergEyes lenses are adjustable parameters. The lens should fit with apical clearance over the central cornea with little or no touch in GP portion of the lens. No bubbles should be present in the central part of lens and light touch should be present at the rigid/soft junction. The SynergEyes lens should land evenly on the soft skirt without impingement or edge fluting. The lens should move slightly with blinking or if the clinician pushes on the lens using the patient’s lower lid. Advantages of SynergEyes lenses include good vision and good lens centration, even for eyes that have advanced keratoconus. Higher oxygen permeability is present centrally and will be available in the near future peripherally. There are a multitude of fitting parameters for base curve and power and various peripheral curve systems. Disadvantages of SynergEyes lenses include late-term lens tightening that can occur months after the initial fitting and the need for highmolecular-weight fluorescein to evaluate the fit. The ideal fit for SynergEyes KC lenses are apical clearance with minimal touch in the rigid portion of the lens and a soft landing where base curve meets the skirt curve.

Soft Lenses and Soft Toric Lenses
Soft spherical or toric contact lenses have a very limited role and are indicated in early keratoconus. The other indications for SCL include intolerance to RGP lenses and discomfort with RGP lenses\textsuperscript{14}.

The various soft toric lenses, which are available, include HydroKone (Medlens Innovations), Soft K (Advanced Vision Technologies), Solus Soft K (Strategic Lens Innovations), Special Eyes 59/54 Toric (SpecialEyes), and Ocu-Flex Toric (Ocu-Ease). These lenses are available with steeper base curves. Kerasoft lenses (UltraVision, UK) are available as either conventional hydrogel or silicone hydrogel lenses. These are similar to soft toric lenses with a single laser marking at the 6 O’clock position to assess the rotation. The rotation should be minimal.

ACT (Asymmetric Corneal Technology)
By nature, the keratoconic cornea is asymmetric, where the inferior quadrant is frequently significantly steeper than the superior portion, causing the GP lens to lift off at 6 o’clock (see illustration E).

Rose K lenses incorporating ACT are designed to accommodate this asymmetry (good edge lift at 3, 9 and 12 o’clock but lift at 6 o’clock). The inferior quadrant of the lens is steeper than the superior quadrants, providing a more accurate fit at 6 o’clock, which makes the lens more comfortable and stable (see illustration F) and often provides superior vision. ACT is independent of the primary base curve and edge lift value and is available for Rose K, Rose K2, Rose K2 IC, and Rose K2 Post Graft lens designs.

Advances in instrumentation and lathing technology have significantly improved the diagnostic and fitting success for irregular corneal management. Now more and more patients with irregular cornea can be successfully fitted with appropriate contact lenses with marked improvement in vision quality.

References


