

# A new technique for fitting of tricurve rigid gas-permeable contact lens in penetrating keratoplasty eyes using Scheimpflug imaging

Pratik Gogri, Faiza A Bhombal

**Purpose:** Rigid gas-permeable (RGP) contact lens fitting after penetrating keratoplasty (PK) is challenging due to significant irregular astigmatism. The aim of the study was to determine a guideline for selecting the initial base curve (BC) of the RGP contact lens fitting in post PK eyes. **Methods:** The data of patients who had tricurve RGP contact lens fitting post PK were collected retrospectively. The following data were collected: best-corrected visual acuity with glasses and contact lenses; contact lens parameters which included the BC and diameter; corneal topography parameters which included steep keratometry value (K), flat-K, and mean-K; and anterior best fit sphere (BFS) measured using Scheimpflug imaging. **Results:** The median age of the 40 subjects (46 eyes) who met the inclusion criteria was 37.5 years (IQR 26.7–45.5). The spherical equivalent was  $-3.00$  diopter (D) ( $-8.31$  to  $-1.56$ ). The median steep-K, flat-K, and mean-K in them were 6.76 mm (6.28–7.07), 7.78 mm (7.37–8.14), and 7.26 mm (6.93–7.46), respectively. The median anterior BFS value of the transplanted cornea was 6.96 mm (6.6–7.37). The median BC of the final RGP lens was 7.0 mm (6.7–7.23) and the median diameter was 9.8 mm (9.4–10.4). Among all the Scheimpflug imaging parameters, the BFS correlated well with the final BC of the RGP contact lens dispensed ( $R\ 0.742$ ,  $P < 0.0001$ ). **Conclusion:** The anterior corneal surface BFS value can be used as a reference in selecting the initial BC of tricurve RGP contact lens to achieve the best fitting and reducing the chair time of patients after PK.

**Key words:** Best fit sphere, keratoconus, penetrating keratoplasty, rigid gas-permeable contact lens, Scheimpflug imaging

Penetrating keratoplasty (PK) is a surgical technique in which the full thickness of the cornea is removed and replaced with a healthy donor corneal tissue. PK is performed in conditions where the nonsurgical optical modalities do not yield a good visual outcome such as various corneal ectasias, especially keratoconus, corneal scarring due to trauma or healed infection, corneal opacity, and keratopathy.<sup>[1]</sup> This was established in the 19<sup>th</sup> century and is still continuing to evolve. Despite the recent advances in surgical techniques, it has been observed that these eyes tend to have a high magnitude of irregular astigmatism and astigmatic anisometropia postoperatively, which cannot be corrected adequately with a spectacle prescription.<sup>[2]</sup> Contact lenses have been the preferred choice for optical correction in these eyes.<sup>[3]</sup> Rigid gas-permeable (RGP) contact lenses are considered as the first lens of choice for the optical management in post PK eyes.<sup>[4,5]</sup> It provides good visual rehabilitation as the tear lens compensates irregular astigmatism and provides better visual quality.<sup>[6]</sup>

Various contact lenses are available for optical management of different ocular conditions in which spectacles fail to provide the maximum visual acuity. Achieving a good contact lens fitting in high refractive errors and regular corneal curvature is easy and less time consuming than in irregular corneal surfaces such as in corneal ectasia, corneal scars, and post PK.<sup>[7-9]</sup> To achieve the best fitting of contact lenses in minimum trial lens

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attempts and to reduce the chair time of patients with irregular corneas, multiple strategies have been established such as using various corneal topography modalities for better understanding the corneal curvature, new lens designs specifically designed for the irregular corneas, and various nomograms for the trial lens.<sup>[10,11]</sup> The use of videokeratography for fitting RGP contact lens in keratoconus and PK has been reported earlier.<sup>[12,13]</sup> In keratoconus, the average flat corneal curvature of the 3.00 mm zone is helpful in determining the initial contact lens parameters using the videokeratography.<sup>[12]</sup> Later studies found that simulated keratometry (K) value using an axial map derived from videokeratographic data was better compared to the instantaneous map to predict the base curve (BC) of the RGP contact lens.<sup>[14,15]</sup> On the contrary, in PK eyes, the average K value of the transplant wound is used as a starting point for selecting the initial BC to fit the RGP contact lens.<sup>[13]</sup>

However, there is no standard criterion to select the BC in the eyes after PK with the help of Scheimpflug imaging of the cornea. The aim of this study is to determine the guideline for selecting the initial tricurve RGP contact lens BC parameter based on corneal topography conducted by Scheimpflug imaging in patients who have undergone PK.

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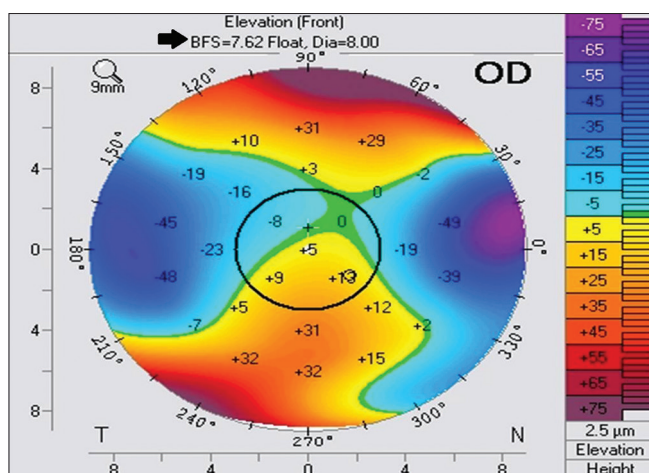
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## Methods

Data of patients who underwent RGP contact lens trial after PK between the time period of May 2016 and May 2017 were analyzed retrospectively. Patients who had a clear graft post PK, with no sutures, minimum postoperative period of 24 months in one or both eyes, referred for RGP contact lens trial for visual rehabilitation, and a minimum follow-up along with use of 6 months after prescribing RGP contact lens were included in the study. Patients with retinal pathology affecting the vision and any other ocular abnormality in the eye were excluded from the study. 46 eyes of 40 patients were included in the study. Ethics committee approval was obtained from the Institutional Review Board. The tenants of the Declaration of Helsinki were followed.

All the patients were fitted with tricurve aspheric RGP contact lenses with a material of high oxygen permeability (Dk value 100). The fitting was done by qualified and experienced optometrists at a tertiary eye care hospital in south India. Although there were multiple practitioners involved in the contact lens fitting, the practice pattern of selecting the BC for initial RGP contact lens remained the same among all of them. The BC selection for the initial RGP contact lens trial was done using the mean keratometry (Rm) value which was obtained from the corneal topographer using Scheimpflug imaging (Wavelight® Oculyzer II, Alcon). The diameter of RGP contact lens was selected depending on the size of the graft. Based on the fitting of the initial RGP contact lens, various BC and diameters were tried to achieve an acceptable fit. RGP contact lens fit was considered acceptable if the lens was well centered with optic zone covering the pupillary area, diameter extending just outside the graft host junction, lens movement of around 1 mm post blink, lens stability in all gazes, adequate tear exchange, and a pattern of diffuse fluorescein in the center and periphery along with clinically significant improvement in vision (2 or more lines) with the contact lens. For all patients, the corneal topography using Scheimpflug imaging was conducted and the following parameters were considered for the comparisons and analysis: steep K, flat K, Rm value for the 3 mm, and the anterior best fit sphere (BFS) value [Fig. 1] for the 8 mm zone. The correlation was calculated between



**Figure 1:** Representative picture of the anterior best fit sphere (BFS) value (black arrow) found on the Refractive Map of Wavelight® Oculyzer II, Alcon

the abovementioned parameters and the BC of the final RGP contact lens with acceptable fit dispensed to patient to find out the best predictor of BC. The Shapiro–Wilk normality test was performed and the data were found to be not normally distributed. Nonparametric statistical tests were applied for the data analysis.

## Results

The median age of the 40 patients was 37.5 years (interquartile range 26.7–45.5). Forty-six eyes of 40 patients were included in the study, out of which 32 subjects were males (80%) and 8 (20%) were females. Twenty-four subjects (52.2%) of the total cohort underwent right eye PK and 22 (47.8%) subjects underwent left eye PK who were diagnosed with various corneal conditions. The most common indication for undergoing PK was keratoconus which accounted for 43.5% ( $n = 20$ ) followed by microbial keratitis 28.3% ( $n = 13$ ); other indications are listed in Table 1. The median spherical equivalent (SE) in the eyes that underwent PK was  $-3.00$  diopters (D) ( $-8.31$  to  $-1.56$ ) and astigmatism was  $-5.00$ D ( $-7.00$  to  $-2.75$ ). The median postoperative period of the group of patients was 47.5 months (16–108).

The indications for RGP contact lens in patients were high astigmatism (astigmatism  $>3$ D) which was found in 20 eyes (43.5%), 12 patients (26.1%) had significant spherical anisometropia (SE difference  $>1.00$ D between two eyes), and spherical anisometropia with high astigmatism was found in 10 eyes (21.7%) [Table 2]. The median spherical anisometropia for 22 eyes was  $-5.75$ D ( $-10.00$  to  $-2.25$ ) and astigmatism for 30 eyes was  $-6.00$ D ( $-9.00$  to  $-5.00$ ). The median logMAR high contrast visual acuity (HCVA) was 0.43 logMAR units (0.32–0.6) with glasses which improved to 0.09 logMAR units (0–0.3) with contact lens ( $P < 0.0001$ , Mann–Whitney U test).

The median number of lenses required to achieve the final acceptable fit was 3 (range 2–5). The final BC of RGP contact lens dispensed to patients had a median of 7.0 mm (6.7–7.23) and diameter of 9.8 mm (9.4–10.4). The median steep K, flat k, and Rmin of the transplanted cornea were 6.76 mm (6.28–7.07), 7.78 mm (7.37–8.14), 7.26 mm (6.93–7.46), respectively. The median BFS was 6.96 mm (6.6–7.37).

**Table 1: Indications for Penetrating Keratoplasty (PK)**

| No. of Eyes | Indication for PK | Percentage |
|-------------|-------------------|------------|
| 20          | Keratoconus       | 43.5%      |
| 13          | Keratitis         | 28.3%      |
| 10          | Corneal Dystrophy | 21.7%      |
| 2           | Corneal Scar      | 4.3%       |
| 1           | Unknown           | 2.2%       |

**Table 2: Reasons for contact lens (CL) referral after PK**

| No. of Eyes | Reason for CL referral                        | Percentage |
|-------------|---|------------|
| 20          | High Astigmatism                              | 43.5%      |
| 12          | Spherical Anisometropia                       | 26.1%      |
| 10          | Spherical Anisometropia with High Astigmatism | 21.7%      |
| 4           | Graft Ectasia                                 | 8.7%       |

Univariate regression analysis was done to find the relation between the BC of the final contact lens dispensed with the topography parameters of the patient, which showed all topography parameters to be statistically significant [Table 3]. Multiple regression analysis was performed keeping the final BC of the contact lens value as the dependent variable and steep K, flat K, Rm, and anterior BFS as independent variables which showed only BFS to be the significant factor (co-efficient:  $0.63 \pm 0.12$ ;  $P < 0.0001$ ) in choosing the final BC of RGP contact lens in PK eyes.

To investigate further regarding the variation of BFS value between keratoconus and PK eyes, a separate analysis was performed. Twenty eyes each of keratoconus and PK with a similar magnitude of astigmatism were studied and anterior BFS values were compared [Table 4]. There was no statistically significant difference between astigmatism in both the groups, while there was a significant difference found between the BFS values ( $P = 0.001$ , Mann-Whitney U test).

## Discussion

Corneal astigmatism after PK has a multifactorial etiology related to intraoperative and postoperative factors.<sup>[15]</sup> Most of these factors cannot be titrated to reduce astigmatism after PK. On an average, there is a residual irregular astigmatism to the tune of 3.00D after PK.<sup>[16]</sup> High irregular corneal astigmatism has always been a cause of poor visual outcome after PK.<sup>[15,17]</sup>

There are various options available for correcting post-PK corneal astigmatism such as spectacle lenses, contact lenses, astigmatic keratotomy, excimer laser, and toric intraocular lenses.<sup>[16]</sup> The RGP contact lens is considered to be the gold standard for correcting irregular corneal astigmatism.<sup>[18,19]</sup> Genvert *et al.* showed that RGP contact lenses can achieve the optimal vision in patients after PK who are unable to achieve the same vision with spectacles.<sup>[20]</sup> Bandela *et al.* reported that RGP contact lenses improve the suppression threshold and stereoacuity in patients who have undergone PK in one eye.<sup>[21]</sup> RGP contact lens use after PK is considered to be safe if an acceptable fitting is achieved. In addition, RGP contact lenses do not affect endothelial cell density in eyes with corneal transplants even if the lenses are worn on a daily basis.<sup>[22]</sup> Scleral contact lenses are also considered one of the options for visual

rehabilitation after PK as they provide comfort by not letting the contact lens touch the cornea.<sup>[23]</sup> The diameter of these lenses ranges from 15.0 mm to 24.0 mm. Scleral contact lens sometimes causes conjunctival compression, swelling of the limbal area, and decrease in tear exchange leading to corneal decompensation, corneal hypoxic changes, severe epithelial keratopathy, and corneal ischemia which can cause an episode of graft rejection or graft decline.<sup>[24,25]</sup>

For fitting RGP contact lens, the BC and diameter are the main parameters which should be considered.<sup>[26]</sup> The conventional method of fitting RGP contact lenses cannot be used in post PK eyes because of the variable curvature observed from the center to the periphery due to the graft host junction and suture-induced astigmatism.<sup>[27]</sup> RGP contact lens fitting after PK is considered to be challenging due to the complex shape of the cornea after surgery.<sup>[9]</sup>

After PK, the size of the corneal graft plays an important role in determining the diameter of the RGP contact lens.<sup>[28]</sup> Generally, a large diameter RGP contact lens is required in the majority of post PK eyes so that the optic zone of the lens covers the entire graft.<sup>[18]</sup> For selecting the BC of the initial trial contact lens, over the years, various approaches have been described using the Placido-based corneal topography. Genvert *et al.* used the Haag-Streit keratometer for fitting RGP contact lenses in PK eyes. He found that if the difference between the flat K and steep K was less than 5D, then flat K can be considered for the initial trial of the contact lens. In comparison, if the astigmatism was more than 5D, then the initial trial lens was usually steeper than flat K.<sup>[20]</sup> Later Manabe *et al.* used photokeratoscopy by calculating the average keratometric readings of blurred images of high irregular curvatures.<sup>[29]</sup> Sharon Ho *et al.* recommended an average K of the topography, that is, the average of the central and peripheral corneal radii or topography value at 1.5 mm above the central cornea as the initial BC for fitting contact lenses in post keratoplasty cornea.<sup>[9]</sup> Eggink and Nuijts used videokeratograph by using the dioptric value over the transplant wound as the initial BC for post keratoplasty cornea.<sup>[13]</sup>

With the development of slit imaging and Scheimpflug imaging technology, mapping the posterior surface of the cornea became a possibility.<sup>[30]</sup> The data obtained by the elevation-based topographers lack qualitative patterns for interpretation. For the purpose of giving qualitative parameters to the elevation data obtained from the new elevation-based corneal topographers, the concept of BFS was used as a reference surface.<sup>[31,32]</sup>

This study has three limitations. First, the study includes only tricurve RGP contact lens although theoretically multicurve RGP contact lenses provide optimal fitting but in our clinical experience tricurve RGP contact lenses provide equally good fitting with the added advantage of being cost effective. The cost factor is quite important, especially in a developing country. Second, a correlation was not done between the corneal topographic pattern of the PK eyes with the RGP contact lens fitting parameters. Third, the retrospective nature of the study.

## Conclusion

In this study, it was found that the BC of the final tricurve RGP contact lens dispensed to the patient for visual rehabilitation

**Table 3: Univariate regression analysis of Oculyzer II Indices with base curve**

| Topography parameter | R (Spearman Rho) | P       |
|----------------------|------------------|---------|
| Steep K              | 0.396            | 0.00634 |
| Flat K               | 0.468            | 0.00102 |
| Mean K               | 0.493            | 0.00049 |
| Best Fit Sphere      | 0.742            | <0.0001 |

**Table 4: Differences among steep keratometry (K), flat K, and BFS in Keratoconus and PK eyes**

| Topography parameter | Keratoconus      | Penetrating Keratoplasty | P     |
|----------------------|------------------|--------------------------|-------|
| Steep K (mm)         | 6.73 (6.46-6.93) | 6.81 (6.34-7.07)         | 0.70  |
| Flat K (mm)          | 7.31 (7.2-7.6)   | 7.37 (7.07-7.71)         | 0.54  |
| Best Fit Sphere (mm) | 6.30 (6.16-6.37) | 6.80 (6.48-7.26)         | 0.001 |

after PK was very close to the anterior BFS value. Hence, using the anterior BFS value as the starting point for the initial trial lens in RGP contact lens fitting in PK eyes can significantly reduce the number of lens trial required before we get an acceptable fit. This, in turn, will help us to reduce the clinic chair time of each patient. However, a prospective study will help us to validate these considerations.

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#### Conflicts of interest

There are no conflicts of interest.

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