Rigid Gas Permeable Contact Lenses for Irregular Corneas and High Astigmatism

[1] Optom. Rupal Baraskar, [2] Optom. Rishabh Gupta

[1] Postgraduate Student, [2] Postgraduate Student

Department of Optometry

Bharati Vidyapeeth (DU) Medical College, School of Optometry, Pune, India

Abstract:
The main refractive surface of the eye is cornea. It makes a small change in corneal radius which makes a large effect on power and has a largest change in the refractive index. Due to the toricity of the anterior corneal surface more number of astigmatisms are produced. Retina –induced and lens induced astigmatisms are known as internal astigmatism. The corneal surface is responsible for most of the astigmatisms. Based on the perpendicularity of the principle meridians of the cornea in regular and irregular corneas, astigmatisms are classified.
To be precise less than 11% RGP has been fitted all around the globe over the last decade. As we know that RGP has more advantages over soft lenses when it comes to physiological wellbeing of the eye specially in the patients with dry eye or giant papillary conjunctivitis, RGP provides greater tolerance and the feature of tear exchange gives the superior physiological interaction between the lens and the ocular surface, and high oxygen transmission provides excellent vision and effective correction to the patients with high astigmatism as an end result.
Conclusion: In cases of irregular astigmatisms management of patients with Contact lens could be an option to improve the visual acuity then with spectacles. Patients with regular astigmatisms can be corrected with soft or RGP toric contact lenses, but if there is a case of irregular astigmatism then it is best corrected with RGP lenses with the help of corneal topography. The tear lens produced because of RGP lens in the patients with an astigmatism provides optimal correction of the regular and irregular astigmatism and provide best visual acuity to the patient.

Keywords: Rigid Gas Permeable Lenses, Irregular Astigmatism, Irregular Cornea.

Introduction

The main refractive surface of the eye is cornea. It makes a small change in corneal radius which makes a large effect on power and has a largest change in the refractive index. Due to the toricity of the anterior corneal surface more number of astigmatisms are produced. Retina –induced and lens induced astigmatisms are known as internal astigmatism. The corneal surface is responsible for most of the astigmatisms. Based on the perpendicularity of the principle meridians of the cornea in regular and irregular corneas, astigmatisms are classified.

For measuring the corneal curvature, the most commonly used instrument is Keratometry. For full corneal assessment corneal topography is performed but it has some disadvantages also. Some disadvantages are errors in alignment, focusing, calibration and soft and hardware data interpretation.

Corneal topography is very useful method to assess and classify corneal astigmatism. Different topography devices generates color-coded maps of corneal curvature. Steeper points of the cornea are represented by hot colors (red) and flatter portion of the cornea are represented by cool colors (blue). The two perpendicular main meridians in corneal topography interprets regular astigmatism. The corneal topography which does not have two perpendicular meridians interprets irregular astigmatism.

Spectacles should be considered for correction of refractive errors before contact lenses and refractive surgery. In cases like irregular astigmatism contact lenses will be the choice method. If the primary meridians are perpendicular then only the astigmatism compensation is possible with spectacle lenses. Spectacle correction for irregular astigmatism is difficult as subjects often complain of blurring, monocular diplopia, or polyopia. For correcting regular astigmatism, standard ophthalmic lenses, contact lenses and surgical procedures are the choices. The visual acuity can be lower than expected while correcting irregular astigmatism with glasses. The better way to improve visual acuity is contact lenses.

To correct refractive errors, contact lenses are an adequate device. The sum of corneal astigmatism and lenticular astigmatism leads to refractive astigmatism. Contact lenses must consider both types of ocular astigmatism while correction.

The rigid plastic material that transmits oxygen to the cornea is RGP contact lens. It has lower diameter than cornea. As we know that soft contact lens conforms the shape of cornea because of its soft nature but RGP cannot, hence it forms a post lens tear film which is called as tear lens with some amount of refractive power, the front surface of tear lens is the posterior surface of cl and the back surface of tear lens is the anterior surface of cornea but both the surfaces are not parallel. The difference in curvature between the cornea and the posterior radius of contact lens is known as the power of the tear lens. The tear lens can neutralize more than 90% of the regular and irregular astigmatism as the refractive index of tears and cornea is same. The anterior curvature radius is determined by the back RGP lens radius and the posterior radius coincides with the anterior corneal curvature. The tear lens neutralizes the difference in the power of the steepest and the flattest meridian of the cornea and the contact lens power calculation gets simpler.

In irregular cornea, irregular astigmatism is the most common form. Accident or eye surgery, corneal refractive surgery which leads to corneal ectasia may cause irregular astigmatism. Due to corneal scarring, Keratoconus, Pellucid marginal degeneration may also lead to additional irregularities. These can lead to reduced quality of life and limitations in vision.

According to the researches, different types of contact lenses such as RGP lenses, Rose-K family lenses, Scleral lenses of various designs, materials and diameters can treat or correct these conditions. Piggyback and hybrid lenses can also treat these conditions. The best optical correction for irregular corneas and irregular astigmatism is by managing them with RGP lenses, Scleral lenses and Rose –K lenses.

Since 1888 Rigid contact lenses have been used to correct refractive errors. Large diameter scleral lenses that used oxygen permeable material were designed initially. Gas permeable (GP) materials with small diameter corneal lenses were introduced in 1970's. Patient tolerance and reduced CL complications were improved with RGP lenses. The development of high oxygen permeability materials were approved for continuous wear with advancements in manufacturing technology. More than 125 million people worldwide are estimated to wear contact lenses.

To be precise less than 11% RGP has been fitted all around the globe over the last decade.[1] As we know that RGP has more advantages over soft lenses when it comes to physiological wellbeing of the eye specially in the patients with dry eye or giant papillary conjunctivitis, RGP provides greater tolerance and the feature of tear exchange gives the superior physiological interaction between the lens and the ocular surface, and high oxygen transmission provides excellent vision and effective correction to the patients with high astigmatism as an end result.

In a study it is stated that 'Gas permeable lens wearers experience a lower number of CL related complications than soft CLs wearers, and they have a lower incidence of serious complications such as microbial keratitis. It has been already proven that the RGP CLs fittings is lower soft lens prescriptions.[1] From this point we can quote that RGP lenses are not the first-choice of practitioner when it comes to fitting CLs for refractive correction specially for the cases of for myopia, hyperopia, and regular astigmatism .In a study it is stated that a clinician's goal should be "to prescribe a CL from a physiologically adequate material that will have minimal mechanical impact on the corneal surface while providing the required optical correction." As an optometrist if we follow this statement then the number of patient with GP lenses would be more but in reality the poor demonstration by the practitioners and the substantial failure of patients to accept RGP is due to initial discomfort or increased adaptation time for the lens. These are the factors which generally influence the fitting of RGP lenses and the novice practitioners cannot manage the patients when the situation occurs resulting in CL dropout of the patient.

Fortunately, there are many eye care practitioners who still count on GP lenses as their first choice of correction for the patients with irregular cornea after refractive surgery, pellucid marginal degeneration and keratoconus.

A study performed by Sara Otiz et al in 2016 in it is stated that- for subjects with keratoconus, pellucid marginal degeneration, corneal distortion or irregularity, or have undergone refractive surgery or orthokeratology treatment, the percentage of successful GP fits (96.7%) is considerably greater than in subjects with healthy eyes (69.3%). This difference in percentage of successful fits between refractive prescriptions and therapeutic prescriptions could be related to the great improvement obtained in BCVA when GP lenses are used in patients with irregular cornea, which can have a great impact on a patient's quality of life.

The ideal RGP lens fit

The assessment of RGP lens fit involves the evaluation of both static and dynamic state:

1. Centration – While in primary gaze the lens should remain centered over the pupil and this centration should be stable with each blink while looking in different gazes, the lens should remain on the cornea which will minimize the conjunctival staining that can occur from the peripheral curves of the lens.

2. **Corneal coverage** –Ideally, the diameter of the RGP lenses should be smaller than the corneal diameter by 1.5 to 2 mm which will help in tear exchange under the lens and align the lens on the cornea.

3. **Dynamic fit** - Movement of the lens on cornea is the most important characteristic feature of an ideal RGP fit .Ideally with each blink the RGP should move around 1 to 1.5 mm. The movement should not be obstructed and must be smooth in vertical meridian. The lens movement is influenced by eyelid force or due to upper lid attachment .If the movement is excessive it may cause corneal or conjunctival staining which will lead to discomfort and inconsistent vision.

4. Alignment - This is the most important the aspect of RGP lens fitting .The ideal RGP should align its back surface with the cornea over most of the surface .Edge clearance at the periphery has to be narrow but optimal so that adequate tear exchange can occur. The alignment of the back surface with the cornea allows the force of the lens to be distributed across the maximum bearing surface of the cornea. In the mid-periphery region there has to be slight corneal touch which will enhance lens centration. In the central part slight apical clearance must present .If excessive clearance is there the lens will be unstable and the patient will experience discomfort and poor vision.

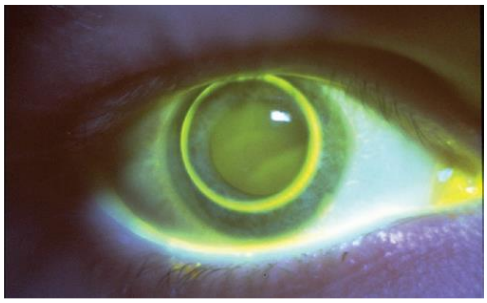

Fig 1. Ideal RGP lens fit

Toric RGP Fitting

Generally it is seen that a spherical RGP can be fitted over the cornea with astigmatism of -2.00DC to -2.50 DC but it gives unsatisfactory fit when astigmatism is more than -2.50 DC, in these cases the back surface toric lens is ideal lens design, with these lenses the back surface radii of the lens coincides with the front surface radii [steepest and flattest radii] of the cornea as measured by Keratometry which provides better stability and comfort to the wearer.
This back surface toric RGP on cornea when viewed with bio-microscopy the fluorescein pattern should be similar to spherical RGP on spherical cornea. Because of toroidal back surface and different refractive indices of tear lens and RGP material there will be small amount of induced astigmatism which can be neutralized by giving small amount cylindrical correction on front surface of the RGP. So the final lens will be bi toric lens which will have back surface toricity to correct the corneal astigmatism and front surface toricity to correct the induced astigmatism.

Irregular astigmatism correction with contact lenses

When compared with spectacle correction, RGP lenses as an option to correct the irregular astigmatism provides significant improvement in Visual Acuity. Because of this reason the RGP contact lenses gets the preference to correct the patient with irregular cornea such as Pellucid Marginal Degeneration, Keratoconus, Corneal dystrophies etc. After performing Corneal refractive surgeries, Corneal Keratoplasty RGP can be used to improve the Visual Acuity of the patient. Sometimes the corneal infections can also induce permanent irregular surfaces which can be treated with RGP lenses.[2]

Indication of RGP in irregular cornea cases

Irregular cornea post Refractive Surgery LASIK[2]

A 37-years old Male, with refraction of -11.00 D in both eyes underwent LASIK. The myopic regression is seen and has bad vision when corrected with spectacles shown in
Table 1. In Fig A Corneal topography shows the decentered myopic ablation pattern because of which the quality of vision is reduced. In Fig D it is shown that corneal thickness is reduced so surgical correction was not possible, therefore, to fit RGP lens was the better option with the aim to obtain a regular optical surface. Because the cornea is flatter centrally than peripherally depicting an oblate shape so a reverse geometry design has to be selected so that parallelism can be achieved between the contact lens and the cornea Fig C.

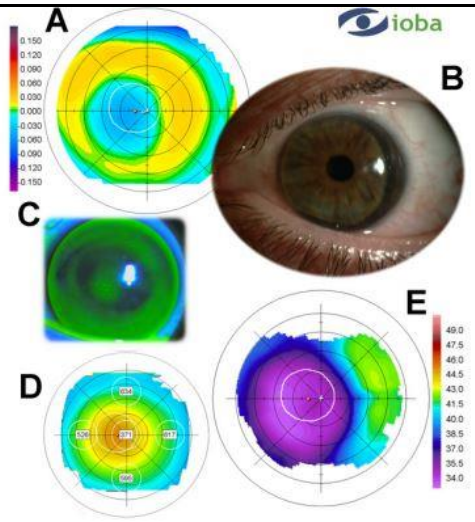

Fig.2

The BOZR of the lens was selected in a manner to achieve corneal alignment between the peripheral cornea and the first peripheral curve so that central pooling can be reduced in the refractive ablated zone and to provide optimal fit in intermediate zone with slightly wide edge clearance. In Fig C, it is showed that moderate pooling at the central [ablated] area and the alignment in mid-peripheral with optimal clearance under the peripheral curve of the contact lens. However vision with the contact lens was very similar to spectacles but the patient reported significant vision improvement. The patient was fitted with a reverse geometry RGP contact lens as it was effective to correct surgically induced irregular astigmatism which also improves patient's vision and comfortable to wear.

Table 1.

VA	Subjective refraction	DCVA	Manual Keratometry	VA with CL
0.16	-5.00	0.7	9.45 mm @ 95° / 9.30 mm @ 5°	0.8

Post-penetrating keratoplasty irregular cornea[2]

A male 25-year-old having history of keratoconus in both eyes and had corneal hydrops in the left eye and can tolerate RGP contact lenses. Penetrating keratoplasty has to be performed so that corneal transparency can be restored Fig A. Corneal transplant was done and got success. Most of the stitches were removed after surgery, but some stitches have remained at the time of discharge, Fig B and because of which patient got 9 diopters of corneal astigmatism Fig C. While performing subjective refraction, the good visual acuity was obtained as shown in the Table.2. But the patient will get high astigmatic aniseikonia with spectacles so the contact lenses was chosen as a mode of correction. There was complete corneal astigmatism with irregular corneal surface which was due to surgical procedure. So preference was given to RGP instead of SCL. Toric back surface RGP was selected. Which gives two different powers, one in each principal meridian.

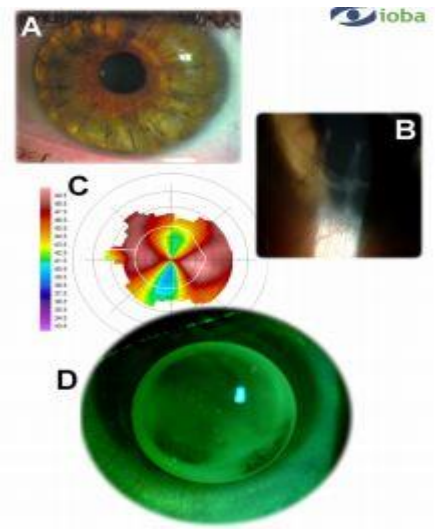

Fig.3

Induced astigmatism can be corrected with the toric front surface so the Bi-toric RGP lens was ordered. The back surface corrects the cylinder because of corneal toricity and the front surface corrects the induced astigmatism. In Fig D the fluorescein pattern is shown, which is showing the parallelism between contact lens the cornea and some irregular areas are also there but without excessive bearing. There is adequate lens movement with optimal tear exchange, and the lens was stable. The visual acuity and subjective tolerance was excellent.

Table 2.

VA	Subjective refraction	DCVA	Manual Keratometry	VA with CL
0.16	+1.00 -9.00 x 80°	1.0	8.30 mm @ 85º /6.60 mm @ 175º	1.5

Rigid gas-permeable contact lens–assisted cataract surgery in patients with severe Keratoconus[3]

"Keratoconus is a non-inflammatory disease characterized by thinning of the central stroma and anterior corneal protrusion" This results in myopia and irregular astigmatism that affects the quality of vision. Management of Keratoconus is a spectrum of therapy that progresses from no treatment to correction with glasses to contact lenses and at last leads to surgery. Treatment is chosen on the basis of disease and visual requirements of the patients. Mild keratoconus can be treated with spectacles and contact lenses. If the degree of cone is progressing and leading to high irregular astigmatism then the contact is the only option.
In the case given below the patient is having keratoconus because of which the Intraocular images become distorted Fig16 but, rigid gas-permeable (RGP) contact lens can be used to reduce the image distortion. In keratoconus patients while performing the cataract surgery, visibility is very poor because of irregular corneal astigmatism that can further lead to complications.

In patients with severe keratoconus cataract surgery is challenging due to poor intraocular visibility. The challenge can be overcome with the help of RGP contact lens. An ophthalmic viscosurgical device OVD can also be used to make the corneal surface smooth while performing surgery, but the RGP contact lens has its own advantage. By using an RGP we can get ideal optical surface irrespective of irregular corneal surface but if we use OVD that will not give regular optical surface because of irregular corneal astigmatism. Hence we can state that the RGP can offer the best visualization in cases with severe keratoconus.

Designing of a RGP lens for a Patient with High astigmatism

There are various software available by which we can design a RGP as per the requirements and can also apply every permutation and combination (changing any parameter like: Steepening and flattening of BOZR, Increase or decrease in Total Diameter of the lens) in the simulated pattern only.
Before Designing one must aware about Corneal Topography and the importance of its various maps so on that basis we can decide that which type of lens has to be used for that specific condition.
While designing a lens we must keep some very important points in our mind so that we can achieve the best fit lens very easily. Designing a RGP is not very difficult if we are clear with the basics of RGP.
The important points that needs to be keep in mind are as follows-

- There has to be 20 microns of fluorescein molecule beneath the lens so that the fluorescein can be visible.
- If the Fluorescein is going beyond 90 microns then it will form a bubble beneath the contact lens.
- The RGP lens should land at 3&9 o' clock position to get an optimal fit and stability on the cornea.

Case Presentation

- Patient came for GP Lens having refractive error in Left Eye is -1.00 DS/-4.25 DC ×170°
- Unaided Vision- 2/60 Pinhole Vision- 6/15p
- Refraction
  - Left Eye -1.00 DS/-4.25 DC ×170° Vn-6/6
- Slit lamp examination was also normal
- TBUT was less than 5 sec.
- HVID was 11mm.
- K readings are – Flat k – 40.86 D @178
  Steep k – 44.93 D @ 88

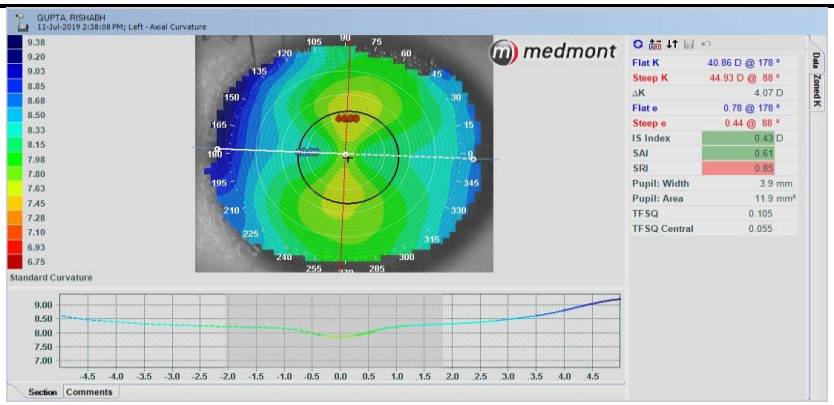

Fig 4. Axial Topography map

- Base Curve Selection
  - Flat K 40.86D @ 178 (8.28mm)
  - Steep K 44.93D @ 88 (7.56mm)
  - Since the Difference between two meridians was more so the average K was taken
  - Average K 7.92mm
- Total Diameter
  - Since HVID was 11.00mm
  - TD was 9.00mm (TD= HVID-2mm)
- Power
  - Firstly a Spherical GP was tried so the value of spherical equivalent was taken and i.e. -3.12DS.

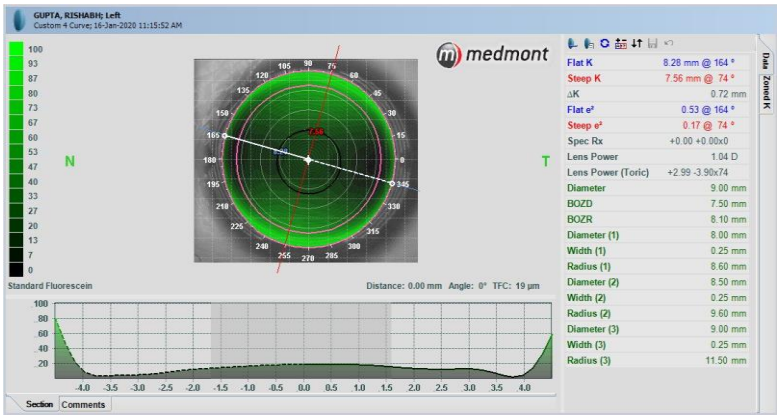

Fig 5. Simulated pattern for the First trial lens

Results of Trial 1.

- A spherical RGP was designed as per the simulated pattern (required changes were made for desired pooling and bearing area).
- TD- 9.00 mm
- BC- 8.10 mm
- Fitting Characteristics : -
  - Centration :- Not centered (low riding lens)
  - Movement : - Rocky Movement
  - Speed of movement : - More than required
  - Vision : - 6/9
- Lens was flat fit with more rocky movement while blinking but the vision was satisfactory.

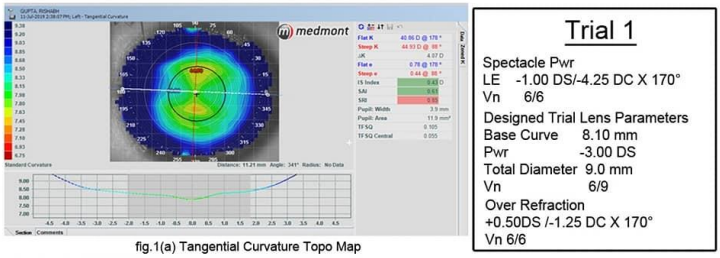

fig.1(a) Tangential Curvature Topo Map

fig.1(b) Stimulated FI Pattern

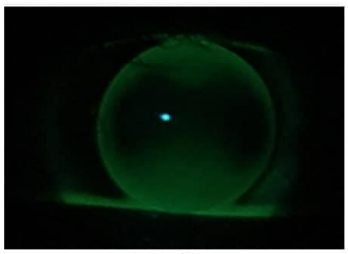

fig.1(c) Actual Lens on eye

Fig 6.

Trial 2.

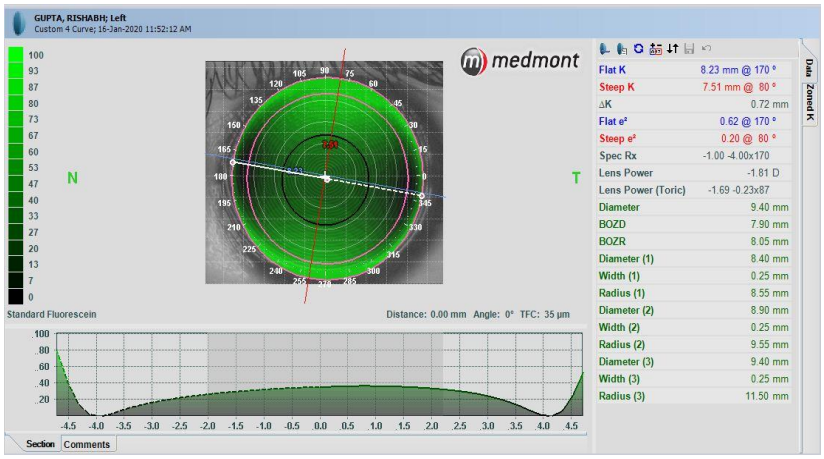

Fig 7.Simulated pattern of Trial 2.

Results of Trial 2.

- A spherical RGP was designed as per the simulated pattern (required changes were made for desired pooling and bearing area).
- TD- 9.40 mm
- BC- 8.05mm
- Fitting Characteristics :
  - -Centration :- Decentered (Slightly Low Riding)
  - Movement : - Optimal Movement
  - Speed of movement : - Close to ideal
  - Vision : - 6/6p
- Lens was almost ideal fit with optimal movement and the vision was even better (able to read 6/6 without over ref.)

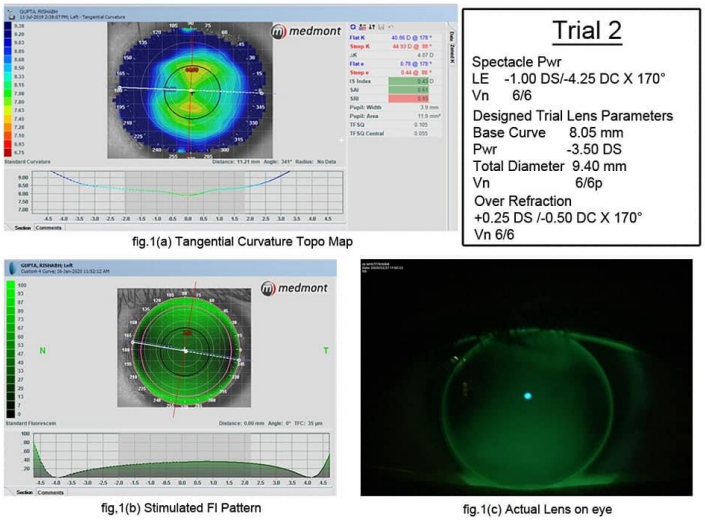

fig.1(a) Tangential Curvature Topo Map

fig.1(b) Stimulated FI Pattern

fig.1(c) Actual Lens on eye

Fig 8.

Conclusion of the case

- The Trial 2 lens was more stable and comfortable from the Trial 1 lens.
- A Bitoric RGP would have been the best option here.
- Bitoric Lens have two toric surface hence it will provide more stability, better comfort and superior Vn.
- Hence, it can be concluded that even though GP lenses are not widely used now-a-days, with better use of technology these lenses can be designed to provide superior vision with optimal comfort.

Simulated pattern of Bitoric RGP

Conclusion

In cases of irregular astigmatisms management of patients with Contact lens could be an option to improve the visual acuity then with spectacles. Patients with regular astigmatisms can be corrected with soft or RGP toric contact lenses, but if there is a case of irregular astigmatism then it is best corrected with RGP lenses with the help of corneal topography. The tear lens produced because of RGP lens in the patients with an astigmatism provides optimal correction of the regular and irregular astigmatism and provide best visual acuity to the patient.

After reviewing several articles and studies it can be concluded that in the case of traumatic corneal astigmatism RGP contact lens is the best choice to identify the visual potential of patients.

It was seen in many studies, corneal ectasia is the most common complication that occurs after refractive surgery, if the proper management is provided then patients can get functional visual acuity. Rigid gas-permeable contact lenses remains at the top in the list of mode of correction for high astigmatism and irregular corneas.

Especially for the patients with keratoconus the use of contact lenses provides the best visual rehabilitation and improves patient's quality of life. Because there are so many options available, different types of lenses can be fitted depending upon the severity of the disease (early stages with soft or corneal GP lenses; mild-moderate with corneal GP lenses, and severe with scleral and corneoscleral contact lenses), helping to delay surgical procedures. If surgery is indicated and post-surgical procedure quality of vision is not up to the mark then in that case we can use RGP lenses to improve the visual acuity of the patient.

As we have seen that there are several software available to design the RGP on your own so with the help of these software we as an optometrist can learn the designing and can design the lenses for the patient and before ordering the actual lens or trial lens we can make the required changes in the simulated pattern itself which also reduces the time to reach the correct lens for the patient.

Hence, by looking all these cases discussed in this article we can state that RGP is still the best choice of correction not only for regular corneas but also for irregular corneas.

References

[1] Ortiz-Toquero, Sara & Martin, Mario & Rodriguez, Guadalupe & De Juan, Victoria & Martin, Raul. (2016). Success of Rigid Gas Permeable Contact Lens Fitting. Eye & contact lens. 43. 10.1097/ICL.0000000000000254.

[2] Herranz, Raul & Zarzuelo, Guadalupe & De Juan, Victoria. (2012). Contact Lens Correction of Regular and Irregular Astigmatism. 10.5772/19001.

[3] Oie, Yoshinori MD, PhD*; Kamei, Motohiro MD, PhD; Matsumura, Nagakazu MD, PhD; Fujimoto, Hisataka MD, PhD; Soma, Takeshi MD, PhD; Koh, Shizuka MD, PhD; Tsujikawa, Motokazu MD, PhD; Maeda, Naoyuki MD, PhD; Nishida, Kohji MD, PhD Rigid gas-permeable contact lens–assisted cataract surgery in patients with severe keratoconus, Journal of Cataract & Refractive Surgery: March 2014 - Volume 40 - Issue 3 - p 345-348 doi: 10.1016/j.jcrs.2014.01.001

[4] Efron, Nathan & Morgan, Philip & Woods, Craig. (2012). International Survey of Rigid Contact Lens Fitting. Optometry and vision science: official publication of the American Academy of Optometry. 90. 10.1097/OPX.0b013e31827cd8be.

[5] Johnson & Johnson Essential Contact Lens Practice. The vision care institute, 2008. Chapter 6.

[6] Waleed Abou Samra MD, Fitting of Challenging Corneas with Special Design of Rigid Gas Permeable (RGP) Lens J. Ophthalmol. Soc. Egypt. 2011 January 104. 35-40.

[7] Morgan, Philip & Efron, N & Hill, Elizabeth & Raynor, Mathew & Whiting, MA & Tullo, AB. (2005). Incidence of keratitis of varying severity among contact lens wearers. The British journal of ophthalmology. 89. 430-6. 10.1136/bjo.2004.052688.