Management of a Post- Radial Keratotomy Patient with Scleral Lenses

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Abstract

One of the earliest types of refractive surgery, Radial Keratotomy (RK), was introduced to the United states in the late 1970s and was hailed as a safe and effective way to eliminate patients' refractive error. Unfortunately, post-RK patients experience a multitude of side effects as a direct result from the surgery, including glare and halos from corneal scarring, fluctuating vision, and high hyperopic refractive error. These symptoms can have an adverse effect of patients' lifestyles. Due to the anisometropia and irregular astigmatism induced by the surgery, these patients can benefit greatly from contact lenses, but remain challenging to fit. This case report details a post- RK patient fit successfully in scleral lenses after trying several other lens modalities with no success.

Key Words*: Radial keratotomy (RK), scleral lenses, irregular astigmatism, corneal scarring*

Introduction

Radial keratotomy (RK) gained popularity as a refractive surgery in the United States in the 1980s and was performed regularly throughout the 1990s. While several techniques exist, each involves making incisions into the cornea with the goal of flattening the cornea and reducing the amount of refractive error. Initial research deemed RK a safe and effective way of eliminating small amounts of myopia.[1,2] Unfortunately, early RK surgery had varying outcomes due to non-standardized surgical techniques and inherent variability in making corneal incisions. The resulting side effects included anisometropia, glare, fluctuating vision, residual hyperopia, and ghosting of images secondary to corneal scarring and irregular astigmatism.[3,4] For these reasons, patients who have undergone RK surgery are some of the most challenging to fit in contact lenses.[5,6] However, they are also some of the patients who can benefit most from contact lenses.

In addition to RK patients, patients with corneal dystrophies or degenerations can also experience anisometropia, irregular astigmatism, and corneal scarring. These conditions, such as keratoconus, have been shown to benefit greatly from contact lenses.[7] The optical properties of contact lenses minimize the effects of these conditions, including blurred vision and ghosting, by effectively giving the eye a new, smooth, ocular surface. Anisometropic patients benefit from the reduction in aniseikonia, which makes correcting these patients with contact lenses more desirable than correcting them with spectacle lenses.[8]

RK patients provide a unique challenge to the contact lens practitioner; they have the potential for all of complications above, plus the resulting post-surgical shape makes fitting lenses that have been traditionally used for other corneal irregularities difficult. After RK, the cornea becomes oblate in shape, with a flatter curve centrally than in the periphery.[9] Most contact lenses are prolate in shape, leading to less than ideal fits for post-RK patients. However, there are specialty lens designs available to aid in the correction of these post-surgical patients.

Currently on the market, there are four different lens types that are typically considered when fitting post-RK patients. These include standard diameter gas permeable (GP) lenses, reverse geometry (RG) lenses, hybrid lenses, and scleral lenses. Each of these lenses has advantages and disadvantages. Visual potential, ocular health, and the patients' goals should all be factors when determining the best lens for the patients' lifestyle.

This case report illustrates the management of a patient with RK who has tried several different lens modalities. It will examine why the previous lens modalities were unsuccessful for the patient and will demonstrate a lens fit that is ultimately successful for the patient.

Case Report

A 53 year old male was referred to the clinic for a contact lens fit. His chief complaint included glare, fluctuating vision and shadowing of images that began a few months following radial keratotomy (RK) surgery in 1998. Since that time, the patient reports being fit in several different modalities of contact lenses. Standard diameter gas permeable lenses, custom soft lenses, hybrid lenses, and most recently, reverse geometry gas permeable lenses were all attempted by previous practitioners and each of these lens types were ultimately deemed unsuccessful for a variety of reasons. For these lens types, the patient cited poor comfort, blurry vision, and inconvenience as reasons for dissatisfaction.

The patient's medical history was unremarkable. He denied taking any medications and had no known drug allergies. He had a positive ocular history of RK surgery OU done in 1998 with a touch up done to the left eye a few months after the original surgery. From his previous records, he was currently wearing a reverse geometry lens design which provided good vision during the day, but poor comfort and decreased vision upon removal. He reported that when taking the lenses out at the end of the day, he never knew if he was going to be able to see. Upon further discussion, the patient expressed interest in trying any lens modality that would allow him to continue with his current lifestyle, which includes frequent travel for work and multiple sporting activities. His goals for wearing lenses included stable vision that minimized shadowing, all day comfort, and lenses that would not fall out while participating in sports.

While wearing his lenses, the patients entering visual acuity was 20/25 OD and OS. Anterior segment findings upon removal of lenses showed a normal anterior segment, with exception of the cornea. Corneal evaluation revealed twelve radial scars OD/OS with neovascularization in the radial scars present at 4:30 and 7 o'clock OS. Entrance testing, including anterior segment optical coherence tomography (OCT) and corneal topography, was completed.

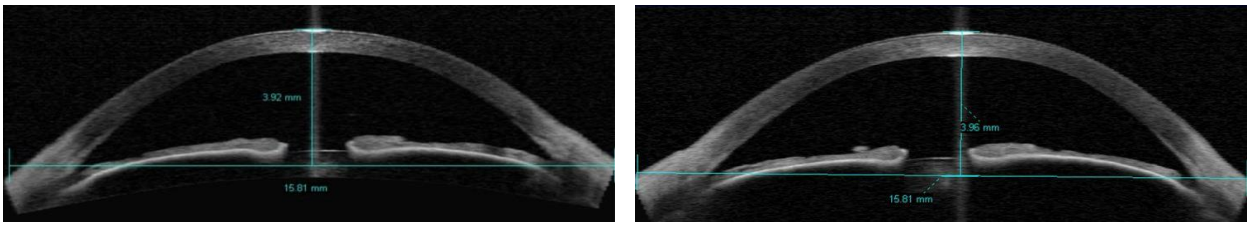

Figure 1: Anterior Segment OCT: OD and OS

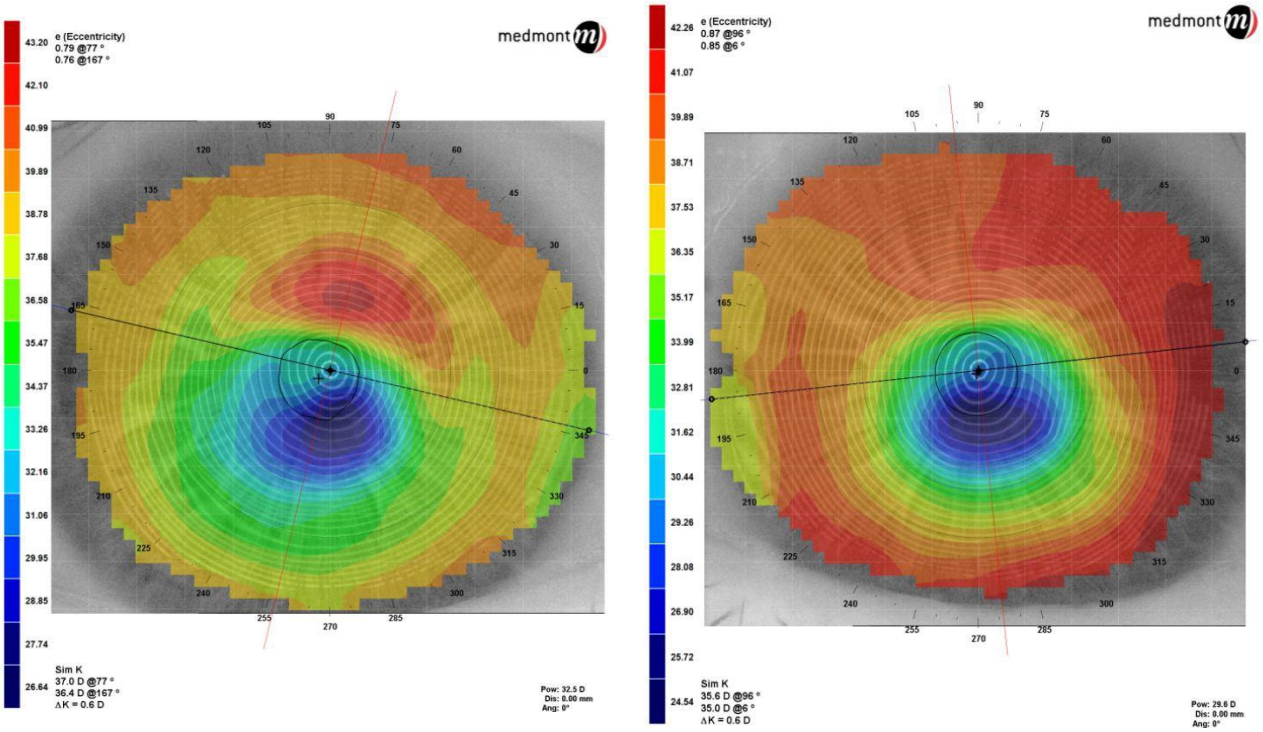

Figure 2: Axial corneal topographies OD and OS

After examining his previous lens history, goals for lens wear, and entrance testing, it was determined that the patient would be fit in a scleral lens. Anterior segment OCT was analyzed to determine initial lens vault required for optimum clearance. Anterior chamber depth was measured at a chord length of 15.8 mm and was 3.92 mm OD and 3.96 mm OS. To these measurements, 400 microns was added to compensate for the tear layer. An initial Valley Contax Custom Stable lens in the Boston XO2 material was used. The lens is a standard prolate shape with spherical peripheral curves. A diameter of 15.8 mm and a sagittal depth of 4.54 mm was chosen, and placed on eye filled with a saline fluorescein solution. The fit was evaluated by comparing the known thickness of the trial lens, 400 microns, and the width of the saline and fluorescein layer.

The initial vault for the 4.54 sagittal depth lens was 450-500 microns centrally, and exhibited clearance to the limbus in all directions with no conjunctival impingement. The lens was allowed to settle for twenty minutes. During that time, the left eye was fit in a lens with a 15.8 mm diameter and a 4.54 mm sagittal depth. The initial clearance was 400 microns with clearance to the limbus in all directions and no conjunctival impingement. After the settling time was completed, both lenses exhibited between 400 to 450 microns of vault, with no peripheral impingement. The over-refraction measured -6.75 OD and -6.00 OS, with distance acuity of 20/20 OD/OS. These powers were vertexed and added to the -2.00D power of the trial lenses. The patient had previously been in monovision, with the left eye being the near eye, and he wished to continue with monovision in his new lenses. The final power for the lenses was -8.25D OD and -6.50 OS, which provided the patient with a +2.12D equivalent add OS.

These lenses were ordered, and the patient was instructed to return in two weeks for a lens dispense and insertion and removal training.

Visit #2

The patient returned after two week for a lens dispense and insertion and removal training. The ordered lens parameters as well as a summary of the lens fit appear in *Table 1*.

Lens parameters	**OD**	**OS**
Power	-8.25 D	-6.50 D
Sagittal Depth	4.54	4.54
Diameter	15.8	15.8
Peripheral Curves	Standard spherical	Standard Spherical
VA	20/20+ Distance	20/25- Near
Clearance	450 microns central	450 microns central

Table 1: Lens parameters and assessment for initial lens

The patient's BCVA with the new lenses was 20/20 OU at distance and 20/25 OU at 40 cm. He reported good initial comfort and clear vision. Anterior segment was unchanged from the first visit.

Insertion and removal training was completed at this visit. The patient was instructed to care for the lenses by using a hydrogen peroxide based solution, which he was using with his current pair of lenses. He was instructed to fill the bowl of the lens with non-preserved saline solution and insert the lenses using a DMV. He reported that insertion was very similar to when he was wearing hybrid lenses. The patient reported feeling comfortable with insertion and removal, so the lenses were dispensed at this visit with the patient scheduled to return for a follow up visit in two weeks to check the fit of the lenses.

Visit #3

At the next visit, the patient returned and reported that vision is excellent, but that the left eye exhibited a progressive soreness throughout the day. At the end of the day, he notices that the left lens is more difficult to remove and takes multiple tries.

The fit of the dispensed lenses and the anterior segment was evaluated at this visit. Lens fit showed good centration and clearance. Tear lens thickness was measured at 350 microns centrally OD/OS. Visual acuity was 20/20 at distance OU and 20/30 at near OU. The anterior segment showed conjunctival entrapment under the lens from 3-6 o'clock inferiorly OD. No

impingement was noted in the lens periphery OU and limbal clearance was adequate. All corneal findings were unchanged from the first visit.

Due to the discomfort and difficulty in removing the left lens, the decision was made to flatten the periphery by one step to loosen the lens fit in the left eye. The new lens was shipped to the patient and he was instructed to return in another two weeks for another follow up.

Visit #4

After using the new lens for a week, the patient returned for his final follow up. He reports that the left lens is much more comfortable, and he no longer has trouble removing the lens. He can wear the lenses comfortably all day, and routinely wears them an average of 14 hours with no fogging or discomfort. Clearance was unchanged from the previous visit at 350 microns OU. Further considerations were made to reduce the clearance of the lens, including switching the lens to a 4.28 sagittal depth, but were decided against at this time due to concerns that this would leave less than 100 microns of central clearance. Flattening the limbal curves was also considered, but discarded due to the amount of limbal clearance present in the current lens fit. BCVA at this visit was stable at 20/20 OU at distance and 20/30 OU at near. At this time, the patient's visual demands were met at both distance and near. He felt able to see his paperwork well at near, so no further changes were made to improve near vision. The patient reports that there is still some ghosting in the left eye, but it is better than it has been in years. When he takes the lenses out at night, he notices his vision is stable, compared to previous lens modalities in which he would never know what his vision would be when he removed the lenses. Anterior segment evaluation was unchanged from the third visit.

At this point, the lens fit was finalized and the patient was instructed to return in six months for an anterior segment evaluation and contact lens follow up. The final lens parameters and assessment can be seen in *table 2*. Lens care was reviewed and the patient was instructed to call if any redness or irritation developed.

Final Lens Assessment	**OD**	**OS**
Power	-8.25 D	-6.50 D
Diameter	15.8 mm	15.8mm
Material	Boston XO2	Boston XO2
Sagittal Depth	4.54 mm	4.54 mm
Peripheral Curves	Standard spherical	1 Flat spherical
Clearance	350 microns	350 microns
Surface quality	Good	Good
VA	20/20 Distance	20/30 near

Table 2: Final lens parameters and assessment

Visit #5- 1 year follow up

The patient recently presented for his yearly follow up with no vision complaints. He stated that the lenses are comfortable, but he occasionally had difficulty removing the right lens at night. His typical wear time for the lenses was between 12 and 14 hours a day and used Clear Care to clean the lenses. He reported no redness, blurry vision, or discomfort with the lenses.

At this visit, the patient had been wearing the lenses for seven hours. Visual acuity was 20/20 OU at distance and 20/25- OU at near. Central clearance showed 350 microns OD, 300 microns OS and adequate limbal clearance. Periphery of both lenses showed no impingement. The anterior segment evaluation with the lenses off was unchanged from the previous year, and showed no corneal staining due to lens wear.

Since the patient was satisfied with the vision of the lenses, no changes were made to the lens powers at this visit. Due to the difficulty removing the right lens, the periphery was flattened one step. The lens was shipped to the patient and he was instructed to return after one week of lens wear.

Visit #6

The patient returned after wearing the new right lens for two weeks. He reported that the right lens was much easier to remove. At this visit, visual acuity was 20/20 OU at distance and 20/30 OU at near. Lens fit showed 300 microns of central clearance OU with adequate limbal clearance and no peripheral impingement. The anterior segment evaluation was the same as the previous visit.

At this time, the lens fit was finalized and the patient wanted to order a backup pair of lenses. He stated that this was the most comfortable lens he has worn in years and his vision is excellent. The patient was instructed to return in one year for his next evaluation.

Discussion

Previously to being successfully being fit in scleral lenses, this patient reported trying many other different lens modalities; each of them was unsuccessful for various reasons. The patient reported that one set would pop out at random intervals, two more offered little improvement in vision, and a fourth provided good vision, but decreased visual acuity after the lenses were removed. Ultimately, it was scleral lenses that could provide the most consistent comfort, stability and visual acuity for this patient.

As reported by the patient, the first lens he tried after his surgery was a standard diameter GP. His reported that these lenses would fall out frequently throughout the course of the day. Patients who have undergone refractive surgery have a more difficult time being successful

with standard gas permeable lens wear. The changed shape of the eye after refractive surgery makes fitting a standard tri-curve lens challenging because these lenses were designed to fit prolate corneas. Patients who have undergone refractive surgery frequently exhibit oblate corneas, which is characterized as a flatter cornea centrally with a steeper corneal periphery.[9] By fitting a standard tri-curve lens based on the peripheral steeper curves, excessive vault is created, which can compromise the lens fit by allowing bubbles to exist under the center of the lens. This can cause discomfort and adverse effects on the cornea, including the development of corneal desiccation. Conversely, if the lens is fit to align with the central flatter curve, it exhibits excessive edge lift. This can cause the lens to catch the lower lid and pop out unexpectedly. Occasionally though, a balance can be found between the flatter central curve and the steeper peripheral curve which allows for a standard tri-curve lens to be fit successfully.

Patients in a poorly fitting tri-curve GP lens can also report significant discomfort with lens wear. There are two types of lenses marketed as being more comfortable for patients while still providing good corneal health and vision. First, there are custom soft lenses available for post refractive surgery patients. Soft lenses have the ability to align better with the cornea, and are less likely to get bubbles. They are also larger in diameters than GP lenses, and as such, will rarely fall out. The disadvantages of these lenses are that vision through soft lenses is generally not as good as with GP lenses. They are prone to rotation and since post-RK patients frequently have some astigmatism present, vision will fluctuate for these patients. One study looking at the feasibility of soft lens wear after corneal surgery found that wearing soft lenses after refractive surgery increases the risk for neovascularization, especially in the radial scars of RK patients.[9] The same risk was not found to be present with gas permeable lenses.

Another comfortable alternative that provides comfort and generally better vision than soft lenses are hybrid lenses. The center gas permeable area corrects for irregular astigmatism better than soft lenses, while the soft skirt helps to provide better comfort than a standard diameter GP.[7] Because these lenses are a combination of a GP and a soft lenses, they contain the best features of both types of lenses, however they also have disadvantages. Some patients experience problems with lens handling. The larger lenses cannot be removed like a soft lens or GP, and must be handled carefully to avoid ripping the lenses. With older generation hybrid lenses, oxygen transmissibility was low, leading to side effects such as neovascularization. Newer hybrids are made with higher Dk materials to minimize this, but the Dk of these lenses is still lower than that of gas permeable lenses.

One alternative to the standard GP tri-curve design is a reverse geometry (RG) design. RG lenses are designed with to more closely align with the oblate shape of post-surgical corneas.[10] This fixes the problem of excessive clearance or edge lift with the standard GP. RG lenses can be fit using a trial lens, or fit empirically with the help of corneal topography. In contrast to tri-curve or aspheric GPs, well-fitting RG lenses should display an even fluorescein pattern on a post-refractive surgery cornea. One drawback to using RG lenses is that some patients will experience fluctuating vision upon removal of the lenses. In fact, this patient was wearing RG

lenses upon presentation to the clinic. He reported that with the lenses in vision was good and the lenses were comfortable, yet he was unsatisfied with these lenses because after taking them out at the end of the day he reported very poor visual acuity. Due to the design of the RG lenses, there can be an increased likelihood of corneal warpage. This lens design is frequently used in orthokeratology to induce corneal molding to correct myopia. If corneal warpage is occurring, patients will report that their vision will be variable after the removal of their lenses. This is problematic for patients because they never know what their vision will be like through glasses after lens removal. Even a lens that displays an even fluorescein pattern and is a good fit can induce corneal warpage.

Patients who have tried the previous lens designs with limited success now have a new option for vision correction. Scleral lenses are gaining popularity with practitioners fitting irregular corneas.[11] Scleral lenses come in many different sizes, and generally run between 14 to 22 mm. The larger diameter generally provides patients with better comfort than standard diameter GP lenses. Since scleral lenses are not fit based on corneal curvature, but rather on sagittal depth, even corneas with high amounts of irregularity can be fit in these lenses. The ideal fit for a scleral lens varies depending on lens design, but all true sclerals will ideally vault the entire cornea, creating a tear lens to correct any irregular astigmatism.[12] These features create a stable, comfortable lens that does an excellent job of correcting refractive error of irregular corneas.

The disadvantages of scleral lenses include more difficult handling and lens fogging. Scleral lenses require the patient to fill the lens with a sterile saline solution and clean the lenses with another solution suitable for GP lens materials. Some patients find using multiple solutions inconvenient and there is increased potential for non-compliance with the increased complexity of caring for scleral lenses. Some patients report that the scleral lenses fog up after a few hours of wear.[13] The fogging can be managed by removing and reinserting the lenses, but some patients may find this inconvenient. However, for patients who have been unsuccessful in other lens modalities, these factors appear to rarely influence the decision to try this lens modality.

Conclusion

Managing patients who have undergone radial keratotomy surgery can be difficult. Modifications to the cornea can lead to scarring, anisometropia, and irregular astigmatism. Patients' symptoms can include fluctuating vision, glare, and the reduction in best corrected visual acuity through spectacle correction. Contact lenses have been shown to minimize side effects from refractive surgery and should be considered as a way to manage these patients' symptoms. With these combinations of factors and the additional change in corneal shape from prolate to oblate, it is important for the practitioner to know all the lens options available to maximize the potential of favorable outcomes for the patient. Depending on the patients' goals and priorities, as well as the practitioners' goal to maintain a healthy cornea, the same lens type may not be ideal for every case. Knowing the advantages and disadvantages can maximize success in this challenging patient population.

References

1. Sawelson H, Marks RG.; Five-year results of radial keratotomy.Refract Corneal Surg. 1989 Jan-Feb;5(1):8-20.
2. Arrowsmith PN, Marks RG.; Visual, refractive, and keratometric results of radial keratotomy. Five-year follow-up. Arch Ophthalmol. 1989 Apr;107(4):506-11.
3. Waring GO 3rd, Lynn MJ, Culbertson W, Laibson PR, Lindstrom RD, McDonald MB, Myers WD, Obstbaum SA, Rowsey JJ, Schanzlin DJ.; Three-year results of the Prospective Evaluation of Radial Keratotomy (PERK) Study.Ophthalmology. 1987 Oct;94(10):1339-54.
4. McDonnell PJ, Nizam A, Lynn MJ, Waring GO., 3rd; Morning-to-evening change in refraction, corneal curvature, and visual acuity 11 years after radial keratotomy in the prospective evaluation of radial keratotomy study. The PERK Study Group. *Ophthalmology.* 1996 Feb;103(2):233–239.
5. Yeung KK, Olson MD, Weissman BA; Complexity of contact lens fitting after refractive surgery. Am J Ophthalmol. 2002 May;133(5):607-12.
6. Bores LD, Myers W, Cowden J.; Radial keratotomy: an analysis of the American experience. Ann Ophthalmol. 1981 Aug;13(8):941-8.
7. Alio´ JL, Belda JI, Artola A, et al.; Contact lens fitting to correct irregular astigmatism after corneal refractive surgery. J Cataract Refract Surg 2002; 28:1750–1757
8. Shivitz IA, Arrowsmith PN, Russell BM; Contact Lenses in the Treatment of Patients with Overcorrected Radial Keratotomy. Ophthalmology. 1987;94(8):899-903
9. Shivitz IA, Russell BM, Arrowsmith PN, Marks RG; Optical correction of postoperative radial keratotomy patients with contact lenses. CLAO J. 1986;12(1): 59-62
10. Lim L, Siow KL, Sakamoto R, Chong JS, Tan DT; Reverse geometry contact lens wear after photorefractive keratectomy, radial keratotomy, or penetrating keratoplasty. Cornea. 2000 May;19(3):320-4.
11. van der Worp E, Bornman D, Ferreira DL, Faria-Ribeiro M, Garcia-Porta N, González-Meijome JM; Modern scleral contact lenses: A review. Cont Lens Anterior Eye. 2014 Aug;37(4):240-50. doi: 10.1016/j.clae.2014.02.002. Epub 2014 Mar 12
12. van der Worp E. A guide to scleral lens fitting. 2015
13. McKinney A, Miller W, Leach N, Polizzi C, van der Worp E, Bergmanson J: The Cause of Midday Visual Fogging in Scleral Gas Permeable Lens Wearers. Investigative Ophthalmology & Visual Science. 2013:54(15), 5483-5483.