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Novel Method to Determine Target Refraction in Cataract Surgery for Patients Dependent on Therapeutic Scleral Lenses

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Objectives: To evaluate a novel approach to determine the refractive target for patients undergoing cataract surgery who are dependent on therapeutic scleral lenses, to avoid the need for postoperative scleral lens replacement.
Methods: Retrospective single-surgeon case series. The target refraction for intraocular lens selection was determined by considering the effective scleral lens system power. This was calculated by adding the known scleral lens spherical power to the difference between the scleral lens base curve and the average keratometry value.
Results: Six eyes from three patients with moderate myopia or emmetropia with ocular graft versus host disease dependent on therapeutic scleral lenses underwent cataract surgery with intraocular lens selection based on this method. All six eyes had corrected visual acuities of 20/30 or better while wearing their previous scleral lenses at the postoperative week 1 visit. All six eyes resumed full-time scleral lens use 1 week after phacoemulsification and did not require scleral lens replacement.
Conclusions: Using this method, patients requiring therapeutic scleral lenses can quickly experience optimal vision, comfort, and ocular surface protection 1 week after cataract surgery. These patients can continue to use their existing scleral lenses and avoid the costs and burdens associated with lens replacement.

Key Words: Cataract—Scleral lens—Phacoemulsification—Lens replacement—Target refraction.

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Allogeneic hematopoietic stem cell transplantation (allo-HSCT) is a potentially curative treatment for various hematologic malignancies. However, it can be associated with significant morbidity and mortality from graft-versus-host disease (GvHD) that affects many organ systems. Ocular GVHD is among the most common forms of chronic GVHD and affects 30% to 60% of patients after allo-HSCT.[1,2] Compromised ocular surface integrity caused by inflammatory keratoconjunctivitis or frank epithelial decompensation can lead to poor vision, chronic ocular irritation, pain, photophobia, corneal ulceration, melt, and perforation, thereby severely diminishing the quality of life in transplant survivors.[3,4] Difficulty with vision is among the most common complaints from the patients because of a compromised ocular surface.[4]

As part of the armamentarium of therapies for ocular GvHD, customized scleral lenses such as PROSE lenses (Prosthetic Replacement of Ocular Surface Ecosystem, Boston Foundation for Sight, Needham, MA) can significantly improve the quality of life in patients with the aforementioned manifestations.[5,6] The expanded precorneal tear film created by the vault of these scleral lenses prevent desiccation of the ocular surface, alleviating symptoms and supporting the injured corneal epithelium. However, these customized prosthetic devices are generally costly and may be limited by regional availability.

Cataracts can be a major cause of visual acuity limitation in this population, attributable to the prevalence of radiation therapy, as well as topical and systemic corticosteroid use.[7,8] Fortunately, cataract surgery can significantly improve vision in these patients.[9–11] At the time of cataract surgery, approximately 15% to 22% of patients with chronic GVHD, likely representing those with more severe ocular surface disease, are reliant on scleral lenses.[9,10] These patients are heavily dependent on the scleral lenses for both comfort and vision, as well as ocular surface protection. It is often impossible to obtain a reliable manifest refraction before cataract surgery in this population because of the dramatic ocular surface deterioration upon scleral lens removal. Patients with GVHD are often expected to resume scleral lens wear approximately one week postoperatively to protect the ocular surface,[9] regardless of the visual outcome. Because of the lack of reliable approach to achieve satisfactory vision upon resumption of the existing scleral lenses, many cataract surgeons choose refractive targets with the anticipation that the scleral lenses will be replaced postoperatively. Not only is this financially burdensome but also the need to replace scleral lenses with a prescription change can lead to unnecessary delay to vision recovery. This is especially pertinent in this vulnerable patient population that already has a significant health care maintenance burden, including unexpected hospitalizations that can further delay the process.

We present a novel approach to reverse calculate the desired refractive aim in patients with well-fitted, properly overrefracted scleral lenses to maximize the immediate postoperative refractive outcome while using the same existing scleral lenses, thereby avoiding the need for replacement in the postoperative period.

METHODS

The retrospective case series included all eyes of patients who were dependent on full-time use of therapeutic scleral lenses because of severe chronic ocular GVHD who underwent cataract

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surgery with refractive targets calculated with the method described by a single surgeon (Z.L.) from January to December 2019. The retrospective chart review was approved by the Partners Human Research Committee of Partners HealthCare. The research was conducted in accordance with the requirements of the Health Insurance Portability and Accountability Act and the tenets of the Declaration of Helsinki.

Biometry of each eye with the scleral lens removed was obtained (LENSTAR LS900, Haag-Streit, Bern, Switzerland, and/or IOLMaster 500, Zeiss, Jena, Germany) with careful attention given to the condition of the ocular surface. Measurements were taken either immediately after the removal of the scleral lens or approximately 3 min after artificial tears are applied to the ocular surface to avoid over- or underhydration of the cornea. Previous records of autokeratometry (Topcon KR-8900), if available, were reviewed and taken into consideration.

The intention of keeping the refractive aim of each eye the same as the preoperative state to continue using the same scleral lenses after cataract surgery were discussed with the patient. After a discussion regarding risks, benefits, and alternatives, the decision was made to use this approach. The base curvature and spherical power of the preexisting scleral lens were obtained from the optometrist who performed the most recent fitting. The effective scleral lens system power was then calculated by adding the known scleral lens spherical power to the difference between the scleral lens base curve and the average keratometry value (K) (Table 1). The intraocular lens power was selected based on the target refraction estimated by the effective scleral lens system power. Minor adjustments were made based on clinical judgment and practice (e.g., targeting −0.25 to −0.50 to minimize hyperopic surprise given the compromised accuracy of K readings because of the irregular corneal surface).

All cataract surgeries were performed at the Massachusetts Eye and Ear Longwood Surgical Center by a single surgeon (Z.L.). Standard phacoemulsification was performed through limbal clear cornea incision under conscious sedation and standard peribulbar anesthesia with 50:50 solution of 2% xylocaine, 0.75% bupivacaine and hyaluronidase. Posterior intraocular lens (Tecnis PCB00, Abbott Medical Optics, Jacksonville, FL) was placed in the intact capsule in all cases. Cefuroxime (1 mg/0.1 mL) or moxifloxacin (0.5 mg/0.1 mL) was given intracamerally at the conclusion of each surgery for endophthalmitis prophylaxis. The operative eye was patched overnight until the postoperative day 1 clinic visit. Topical steroid drops were the only postoperative treatment. Topical antibiotic drops were given only if a bandage contact lens was placed. The first postoperative insertion of the scleral lens was performed by the surgeon at the postoperative week 1 visit to ensure proper fitting and wound integrity. Visual acuity was then measured. Routine full-time scleral lens use was resumed thereafter. Topical steroid drops were self-administered at least 30 min before scleral lens insertion and/or after scleral lens removal for the duration of each postoperative course.

RESULTS

There were a total of six eyes from a total of three patients who were dependent on full-time use of therapeutic scleral lenses in both eyes because of severe chronic ocular GVHD who underwent phacoemulsification by a single surgeon (Z.L.) between January and December 2019. Intraocular lens power was selected based on the calculations described above, and there were no eyes using this method that were excluded during this period. Variables used in the calculation of the refractive target to obtain effective scleral lens system power, with preoperative and postoperative visual outcomes, are summarized in Table 2.

Case 1

A 65-year old man with a history of myelodysplastic syndrome who had undergone allo-HSCT 4 years ago, which was complicated by severe chronic systemic and ocular GVHD, presented with dense nuclear sclerotic cataracts in both eyes. He was on oral prednisone 20 mg and tacrolimus 1 mg daily at the time of the preoperative evaluation. He had severe keratoconjunctivitis sicca and blepharitis in both eyes in the setting of ocular GVHD requiring full-time use of therapeutic scleral PROSE lenses in both eyes. His visual acuity while wearing the scleral lenses was 20/80 in each eye.

In his right eye, he was wearing a PROSE lens with a base curve of 8.4 mm, power of −4.00 diopters (D), and diameter of 18.5 mm. The Ks obtained were 38.94/40.00 (LENSTAR LS900; Haag-Streit, Bern, Switzerland). From these measurements, the reverse-calculated scleral lens system power was −3.25 D. A Tecnis PCB00 22.0D lens was inserted with a target refraction of −3.18 D (Hill-RBF formula). A 1 mm × 3 mm central corneal abrasion was found on postoperative day 4 for which a bandage contact lens was placed. One week (day 8) after the surgery, when the epithelial defect closed, vision with scleral lens in place was 20/30.

In his left eye, he was wearing a PROSE lens with a base curve of 8.4 mm, power of −4.00 D, and diameter of 18.5 mm. The Ks obtained were 38.97/39.86 (LENSTAR LS900; Haag-Streit). The reverse-calculated scleral lens system power was −3.25 D. A Tecnis PCB00 21.0 D lens was inserted with a target refraction of −3.11 D (Hill-RBF formula). A bandage contact lens was placed at postoperative day 1 visit prophylactically. Vision with scleral lens was 20/25 at his postoperative week 1 visit.

The patient's vision subsequently improved to 20/20 in each eye per communication from his referring ophthalmologist. As of 1 year after the surgery, he has not had to replace his scleral lenses.

Case 2

A 73-year-old man with a history of myelodysplastic syndrome who had undergone allo-HSCT 6 years ago, which was complicated by chronic systemic and ocular GVHD, presented with dense diffuse posterior subcapsular cataracts in both eyes that severely compromised his visual function despite seemingly adequate

TABLE 1. *Estimation of Intraocular Lens Refractive Target From Effective Power of Scleral Lens System*

Target refraction = R_{power}	R_{power}: Effective power of overall scleral lens system (diopters)
Target refraction = $S_{power} + T_{power}$	S_{power}: Spherical power of scleral lens (diopters)
Target refraction = $S_{power} + (S_{base} - K_{average})$	T_{power}: Spherical power of tear lens (diopters)
	S_{base}: Base curve of scleral lens in power (diopters)
	$K_{average}$: Average K (diopters)

TABLE 2. *Variables Used in the Calculation of Intraocular Lens Refractive Target Using Effective Scleral Lens System Power in Six Eyes, With Preoperative and Postoperative Visual Outcomes*

	Laterality (Eye)	Scleral Lens Posterior Base Curve (mm)	Scleral Lens Posterior Base Curve (Diopters)	Scleral Lens Power (Diopters)	Ks (Diopters)	Calculated Scleral Lens Power (Rounded to Nearest 0.25 Diopters)	Target Refraction of Intraocular Lens (Diopters)	Intraocular Lens, Power (Diopters)	Preoperative Visual Acuity with Scleral Lens	Postoperative week 1 Visual Acuity with Scleral Lens	Most Recent Postoperative Visual Acuity with Scleral Lens
Patient 1	Right	8.40	40.25	−4.00	38.94/40.00[a]	−3.25	−3.18	PCB00 (22.0)	20/80	20/30	20/20
	Left	8.4	40.25	−4.00	38.97/39.86[a]	−3.25	−3.11	PCB00 (21.0)	20/80	20/25	20/20
Patient 2	Right	7.76	43.50	−1.50	41.87/42.19[b]	Plano	−0.25	PCB00 (21.5)	20/25–3	20/25	20/20–2
	Left	7.85	43.00	−0.25	42.29/42.99[b]	Plano	−0.50	PCB00 (21.0)	20/30–1	20/20	20/20–1
Patient 3	Right	9.00	37.50	−1.50	40.32/40.56[b]	−4.50	−4.50	PCB00 (20.5)	20/70	20/20	20/20
	Left	8.40	40.25	−3.87	40.49/41.22[b]	−4.50	−4.50	PCB00 (20.5)	20/200	20/20	20/25–2

[a]LENSTAR LS900, Haag-Streit.

[b]IOLMaster 500, Zeiss.

Snellen visual acuity. He was on oral prednisone 10 mg and tacrolimus 0.5 mg daily and had recently completed a course of intravenous steroids for babesiosis after which he reported worsening vision. He had severe keratoconjunctivitis sicca in both eyes in the setting of ocular GVHD and relied on scleral lenses in each eye. His preoperative visual acuity while wearing the scleral lenses were 20/25-3 in the right eye, and 20/30-1 in the left eye.

In his right eye, he was wearing a Europa Scleral lens (Visionary Optics) with a base curve of 7.76 mm, power of −1.50 D, and diameter of 16.0 mm. The Ks obtained were 41.87/42.19 (IOLMaster 500, Zeiss, Jena, Germany). The reverse-calculated scleral lens system power was plano. A Tecnis PCB00 21.5 D lens with a target refraction of −0.25 D (Holladay I formula) was inserted. Vision with scleral lens was 20/25 at his postoperative week 1 visit.

In his left eye, he was wearing a Europa Scleral lens (Visionary Optics) with a base curve of 7.85 mm, power of −0.25 D, and diameter of 16.0 mm. The Ks obtained were 42.29/42.99 (IOLMaster 500; Zeiss). The reverse-calculated scleral lens system power was plano. A Tecnis PCB00 21.0D lens with a target refraction of −0.50D (Holladay I formula) was inserted. Vision with scleral lens was 20/20 at his postoperative week 1 visit.

His visual acuities in scleral lenses were 20/20-2 in the right eye and 20/20-1 in the left eye at the 4-month postoperative visit. As of 1 year after the surgery, he has not had to replace his scleral lenses.

Case 3

A 68-year-old woman with a history of chronic lymphocytic leukemia who had undergone allo-HSCT 2 years ago, which was complicated by chronic systemic and ocular GVHD, presented with dense nuclear sclerotic cataracts in both eyes. She had tapered off of oral prednisone at the time of preoperative evaluation. She had keratoconjunctivitis sicca in the setting of severe ocular GVHD, necessitating full-time use of PROSE lenses in both eyes. Visual acuities with the scleral lenses in place were 20/70 in the right eye and 20/200 in the left eye.

In her right eye, she was wearing a PROSE lens with a base curve of 9.0 mm, power of −1.50 D, and diameter of 18.0 mm. The Ks obtained were 40.32/40.56 (IOLMaster 500; Zeiss). The reverse-calculated scleral lens system power was −4.50 D. A Technis PCB00 20.5D lens was inserted with a target refraction of −4.50 D (SRK-T formula). Vision with scleral lens was 20/20 at the postoperative week 1 visit.

In her left eye, she was wearing a PROSE lens with a base curve of 8.4 mm, power of −3.87 D, and diameter of 18.5 mm. The Ks obtained were 40.37/41.06 (IOLMaster 500; Zeiss). From these measurements, the reverse-calculated scleral lens system power was −4.50 D. A Technis PCB00 20.5 D lens was inserted with a target refraction of −4.50 D (SRK-T formula). Vision with scleral lens was 20/20-1 at the postoperative week 1 visit.

At the 6-month postoperative visit, her visual acuities in scleral lenses were 20/20 in the right eye and 20/25-2 in the left eye. As of 1 year after the surgery, she has not had to replace her scleral lenses.

DISCUSSION

Patients with severe ocular surface disease depend on therapeutic scleral lenses for comfort, vision, and ocular surface protection, which are especially important in the vulnerable postcataract surgery period. We present a method of reverse calculating the desired intraocular lens power to allow patients to resume using their previous scleral lenses at the postoperative week 1 visit. The six eyes described in this article demonstrate that excellent postoperative refractive outcomes can be achieved, while promoting comfort and optimal vision in the immediate postoperative period.

Maintaining the ocular surface postoperatively through the timely reintroduction of scleral lens use is also important because the direct trauma and inflammation from cataract surgery, as well as the postoperative topical medication regimen, can exacerbate preexisting keratoconjunctivitis and lead to nonhealing epithelial defects as seen in case 1, corneal ulceration, or even perforation.[9,10,12] Therefore, resuming therapeutic scleral lens use as soon as is safely possible is crucial. However, because of the unique challenge in obtaining an accurate preoperative manifest refraction without the scleral lens in place, it is often frustrating to patients to have to temporarily use their current scleral lens that results in worse vision until a new lens can be manufactured with their new prescription.

To our knowledge, this is the first case series describing the determination of refractive target by calculating the effective scleral lens system power, thereby avoiding the need to replace customized scleral lenses, resulting in excellent refractive outcomes. Williams and Aquavella[13] previously reported a case where the intraocular lens power was partially calculated using biometry measured over a fitted PROSE lens. Using Ks obtained with the scleral lens removed, and axial length measured after the scleral lens was replaced, the authors were able to achieve uncorrected visual acuity of 20/50 after 2 months that improved to 20/30 with manifest refraction. In the six eyes presented in our series, all had visual acuities of 20/30 or better while wearing their preexisting scleral lenses at their postoperative week 1 visit.

Of note, all six eyes were moderately myopic or near emmetropic before cataract surgery. Targeting a refraction in this range is practical because it is compatible with necessary daily activities, such as insertion and removal of scleral lenses. If the preoperative refractive state is hyperopic or highly myopic, it could be beneficial to reestablish a more practical refractive outcome for best uncorrected near and intermediate vision. In the time period of this case series, one other scleral lens dependent patient with bilateral dense cataracts underwent uncomplicated phacoemulsification in both eyes by the same surgeon. Reverse calculation found that the patient was more than 5.00 D hyperopic in both eyes. After careful discussion with the patient, the refractive aim was set at −2.00 D sphere. The patient had an excellent, albeit delayed, visual outcome in both eyes after replacement of his scleral lenses with a new prescription (unpublished clinical data).

Although this method was effective in the cases presented, there may be limitations to this practice. Our approach relies on the assumption that the prescribed scleral lenses were properly fitted and overrefracted to achieve the best possible vision. In addition, reasonably reliable keratometry is needed to perform this calculation. Based on our experience, performing biometry (or autokeratometry) efficiently and immediately after scleral lens removal by an experienced technician is crucial. We also want to emphasize that the decision on when it is safe to return to scleral lens use in the postoperative period should be based on the surgeon's clinical judgment regarding wound integrity and other factors. In some cases, a scleral tunnel approach and/or suture placement at the wound may also be necessary.

Scleral lenses, including PROSE lenses, are powerful modalities that serve a critical role in treating many desperate patients disabled by severe ocular surface disease such as severe dry eye syndrome from autoimmune diseases, chemical burns, neurotrophic keratopathy, cicatrizing conjunctivitis, and ocular GVHD.[14] By minimizing the need for scleral lens replacement after cataract surgery, patients are able to quickly enjoy increased comfort and clearer vision. Such an approach also solves the dilemma of whether to fit scleral lenses in patients with visually significant cataracts requiring urgent ocular surface protection, knowing that they will likely need to be replaced after cataract surgery. The lower overall financial cost of scleral lenses and decreased burden of clinic visits associated with our method will also allow more patients to benefit from these life-changing prosthetic lenses. We will continue to apply this method and refine the approach in future cases.

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