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Descemet Membrane Endothelial Keratoplasty and light adjustable lens triple procedure

H. Carson Eisenbeisz [a,*], Adam R. Bleeker [a], Daniel C. Terveen [a,b], John P. Berdahl [a,b]

[a] University of South Dakota Sanford School of Medicine, 1400 W. 22nd St., Sioux Falls, SD, 57105, USA
[b] Vance Thompson Vision, 3101 West 57th St., Sioux Falls, SD, 57108, USA

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ABSTRACT

Purpose: The objective of this series is to report the early post-operative visual outcomes of a novel triple procedure utilizing Descemet membrane endothelial keratoplasty (DMEK) plus light adjustable lens (LAL) in two patients (four eyes).

Methods: Two patients with bilateral, visually significant cataracts and Fuchs' dystrophy were selected for DMEK plus LAL triple procedure. Patient B also exhibited a high amount of preoperative astigmatism. Both patients desired spectacle independence and were initially targeted for monovision with the dominant eye corrected for distance and the nondominant eye corrected for near. Best corrected visual acuity (BCVA), uncorrected visual acuity (UCVA), and manifest refraction were recorded at each postoperative appointment and light treatment.

Results: In the early post-operative course, Patient A chose to pursue binocular distance correction instead of monovision. This was adjusted for accordingly using the LAL. Following final lock-in, Patient A had a distance UCVA of 20/15 in the right eye (OD) and a distance UCVA of 20/20 in the left eye (OS). Patient B was targeted for monovision. After final lock-in, Patient B had a distance UCVA of 20/15 in the dominant eye (OD) and a near UCVA of Jaeger No. 1+ in the nondominant eye (OS).

Conclusions and Importance: The first reported cases of DMEK plus LAL triple procedures achieved exceptional UCVA at the desired target. The post-operative customizability of the LAL allows for the achievement of excellent refractive outcomes after DMEK, even in patients with significant astigmatism and in patients who change their mind regarding refractive target.

1. Introduction

Descemet Membrane Endothelial Keratoplasty (DMEK), first described by Dr. Gerrit Melles in 2006, is a partial thickness cornea transplant technique in which the corneal endothelium and Descemet's membrane are transplanted.[1] Fuchs' dystrophy is the most common indication for corneal transplants.[2] DMEK continues to gain popularity over its predecessor Descemet Stripping Automated Endothelial Keratoplasty (DSAEK) due to better visual outcomes and increased patient satisfaction,[3,4] including in eyes with concurrent phacoemulsification and intraocular lens (IOL) implantation.[5]

The aforementioned procedure in which DMEK is combined with phacoemulsification and IOL implantation has become known as DMEK triple or DMEK plus and has been described as safe and cost-effective for DMEK patients with concurrent cataract.[6,7] DMEK has been shown to accelerate cataract formation, so a triple procedure is sometimes recommended to avoid later need for reoperation, especially in those over 50 or those with a shallow anterior chamber.[2,8] A staged procedure, DMEK followed by cataract extraction at a later date once the cornea has stabilized, offers the best possible refractive outcome, but carries the risk of multiple intraocular procedures. Furthermore, staged procedures may shorten corneal graft viability as phacoemulsification is a known cause of endothelial cell loss.[2]

Many variables influence the refractive outcome in both cataract extraction and DMEK. For example, DMEK is known to induce a hyperopic shift.[9] Therefore, pre-operative lens selection in combined cases is unpredictable and limits refractive outcomes. This uncertainty is increased when the patient has preoperative astigmatism and/or the surgical goal of monovision. One promising method to improve refractive outcomes in DMEK triple procedures, especially for those with

* Corresponding author. 520 Kansas City St. Suite 200, Rapid City, SD, 57701, USA.
E-mail addresses: carson.eisenbeisz@coyotes.usd.edu (H.C. Eisenbeisz), adam.bleeker@usd.edu (A.R. Bleeker), daniel.terveen@vancethompsonvision.com (D.C. Terveen), john.berdahl@vancethompsonvision.com (J.P. Berdahl).

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astigmatism or the goal of monovision, is use of the RXSight Light Adjustable Lens (LAL). Development of the LAL began in 2003. The lens consists of a photosensitive silicone material which allows for post-operative adjustment using directed ultraviolet (UV) light. The LAL allows for correction of residual myopic and hyperopic spherical error up to two diopters (D) and cylindrical error up to three diopters. These corrections may occur over several post-operative light treatments before the LAL is locked in to a final power.[10–12]

The objective of this series is to report the early post-operative outcomes of a novel triple procedure utilizing DMEK plus LAL in two patients (four eyes).

2. Materials and methods

Patients were selected as candidates for DMEK plus LAL for the indication of Fuchs' dystrophy and concurrent visually significant cataracts. Standard lens options and the possibility of staged procedures were offered. Both patients were highly motivated for spectacle independence. Given the lack of predictability with DMEK plus standard IOL and staged procedures, both patients elected for DMEK plus LAL. The surgical plan was to target both patients for monovision before correcting the residual postoperative refractive error with a digital light delivery device (DLDD).

Informed consent was obtained. Preoperatively, patients underwent examination for manifest refraction, Snellen best corrected visual acuity (BCVA) and uncorrected visual acuity (UCVA), brightness acuity testing (BAT), corneal corrected intraocular pressure (ccIOP), corneal topography, keratometry, and specular microscopy to determine endothelial cell counts. LAL powers were calculated using standard ocular biometry. Each patient was initially targeted for −0.5 D distance vision in their dominant eye and −1.25 or −1.5 D near vision in their nondominant eye. All targets were offset by −0.5 D from the desired outcome to account for postoperative hyperopic shift due to the optics of the corneal graft and posterior lens capsule.

Standard phacoemulsification and LAL implantation followed by a standardized DMEK procedure was performed as previously described by Terry et al.[13] with the modification of a 2.8 mm incision which is required for the LAL cartridge. A 10-0 vicryl suture was placed through the main incision and removed at the one-week postoperative visit.

Patients were examined postoperatively at one day, one week, and two weeks. The first postoperative manifest refraction was recorded once the gas bubble had dissipated and the graft was completely attached. This was typically done at the one-week visit. If there was a need for rebubbling, anterior segment optical coherence tomography was performed. The patients returned for LAL adjustment and lock-in using a DLDD after a period of refractive stability. Refractive stability was defined as two consecutive similar refractions postoperatively. The DLDD protocol has been described in detail elsewhere.[14] The target refraction entered into the DLDD was guided by a combination of the patient's subjective manifest refraction and satisfaction.

3. Results

Baseline visual acuities, glare testing, and endothelial cell counts are summarized for both patients in Table 1. Manifest refractions for both patients throughout the postoperative follow up, DLDD adjustments, and lock-in treatments are summarized in Table 2.

3.1. Patient A

Patient A was a 68-year-old Caucasian male with bilateral, visually significant cataracts and Fuchs' dystrophy. He had no history of refractive surgery. Based on the preoperative measurements, he was targeted for −0.5 D distance vision OD and −1.25 D near vision OS.

DMEK plus LAL surgery proceeded without intraoperative complications. He received a 21.0 D LAL OD followed by a 22.0 D LAL OS one month later. He presented with a partially detached OD corneal graft at the one-week postoperative visit which required rebubbling. During the postoperative course, he chose to instead pursue binocular distance targeted vision as he did not like monovision. The DLDD treatments were adapted to this new target and occurred on postoperative days 22 and 28 OD and 17 and 20 OS. LAL lock-in OD was performed 30 days postoperatively while OS lock-ins occurred 24 and 25 days postoperatively. Following final lock-in, distance UCVA was 20/15 -2 OD and 20/20 + 2 OS.

Table 1
Preoperative vision, glare testing, and endothelial cell counts for all eyes.

	Patient A OD	Patient A OS
UCVA	20/20 -2	20/20 -1
BCVA	20/20	20/20
BAT	20/50	20/50
Endothelial cell density (cells/mm^3)	2358	2232
Central corneal thickness (μm)	584	589
	Patient B OD	**Patient B OS**
UCVA	20/40	20/60
BCVA	20/15 -2	20/15 -1
BAT	20/50	20/150
Endothelial cell density (cells/mm^3)	2262	2653
Central corneal thickness (μm)	571	566

3.2. Patient B

Patient B was a 65-year-old Caucasian female with bilateral, visually significant cataracts and Fuchs' dystrophy. She had no history of refractive surgery. Based on the preoperative measurements, she was targeted for −0.5 D distance vision OD and −1.5 D near vision OS.

DMEK plus LAL surgery proceeded without intraoperative complications. She received a 20.5 D LAL OD followed by a 23.0 D LAL OS one month later. The postoperative visual acuity measurements are summarized in Table 2. She presented with a partially detached OS corneal graft at the one-week postoperative visit and required rebubbling at that time. DLDD treatments occurred on postoperative days 35 and 41 OD and 21, 23, and 28, OS. LAL lock-in OD was performed 55 days postoperatively while OS lock-in occurred 31 days postoperatively. Following final lock-in, distance UCVA OD was 20/15 and near UCVA was Jaeger No. 1+ OS.

4. Discussion and conclusion

Historically, corneal transplant patients have limited options for spectacle independence. DMEK has allowed for consistent and predictable results, raising the expectation considerably for refractive outcomes after corneal transplant.[2] Performing a combined cataract and DMEK triple procedure has proven to be cost-effective, more convenient for the patient, and has not been associated with increased complications.[2,6,7] Choosing the correct IOL for optimal refractive outcomes, however, remains a challenging task. Factors such as existing and surgically induced corneal edema and astigmatism as well as hyperopic shift represent variables to consider when planning IOL choice.[2,15]

Laser refractive surgery after corneal stabilization is a potential option for optimizing results but carries the increased burden of a second surgery for the patient and may not be safe for certain Fuchs' dystrophy patients.[2,16] Yokogawa et al. reported the potential benefit of DMEK plus toric IOL triple procedures for patients with astigmatism, but the refractive outcomes appear somewhat unpredictable. Specifically, intraoperative anterior chamber depth changes during graft unscrolling may induce rotational misalignment of the toric lens.[15] Due to these challenges, a staged procedure of DMEK first followed by cataract surgery remains a viable, yet inconvenient option.[2,15] In this type of staged procedure, graft detachment and endothelial cell loss are concerns

Table 2
Manifest refractions and uncorrected visual acuity (UCVA) at various points pre- and postoperatively. Treatment refers to adjustment of light adjustable lens (LAL) using a digital light delivery device (DLDD). The DLDD is similar to a slit lamp. Patients are dilated prior to each light treatment. The surgeon uses the DLDD to focus UV light on the LAL either condensing or dispersing light sensitive polymers based on the patient's residual refractive error. A total of three light treatments can be completed before final lock-in. Lock-in treatments use a higher intensity of ultraviolet light to solidify the remaining untreated polymer.

	Patient A OD				Patient A OS			
	Sphere	Cylinder	Axis	UCVA	Sphere	Cylinder	Axis	UCVA
Preop	3.00	−0.75	120		3.00	−0.25	55	
1 week postop*	0.25	0	NA	20/50 -2	0.5	0	NA	20/20 -2
2 weeks postop	0.5	−0.75	100	20/20 -1	0.5	−0.5	66	20/20 + 2
1° treatment	1.25	−1.25	127	20/20	0.75	−0.75	50	20/20
2° treatment	−0.25	−0.5	87	20/15	−0.5	−0.5	140	20/15
1° Lock-in	0.25	0	NA	20/15	0.25	−0.5	130	20/15
2° Lock-in	NA	NA	NA	NA	0.25	0	NA	20/20
	Patient B OD				**Patient B OS**			
	Sphere	Cylinder	Axis	UCVA	Sphere	Cylinder	Axis	UCVA
Preop	1.00	−2.00	74	20/40	1.00	−1.00	100	20/60
1 week postop*	0	0	NA	20/15	−1.00	−0.5	135	20/30 -1
2 weeks postop	−0.5	0	NA	20/20 -3				
1° treatment	1.00	−1.25	65	20/20 -1	0	−0.5	120	Jaeger 3
2° treatment	−1.25	−0.5	165	20/20 -2	−1.00	−0.25	121	Jaeger 1+
3° treatment	NA	NA	NA	NA	−1.25	−0.5	113	Jaeger 1
1° Lock-in	0	−0.25	106	20/15 -2	−1.75	0	NA	Jaeger 1+

* indicates time of rebubbling for partial graft detachment.

during phacoemulsification. However, a "soft-shell" technique using dual viscoelastic has been employed to minimize endothelial cell loss to an acceptable level of 5% and graft detachments appear to be uncommon.[8,17,18]

The potential pitfalls of a combined triple procedure using the LAL are presumed to be similar to those of other triple procedures. Retained viscoelastic from the cataract extraction portion of the procedure may interfere with graft attachment. Because of this, it is crucial that all viscoelastic material is removed before the graft is introduced. Additionally, the newly implanted and unstable IOL has the potential to move anteriorly and contact the graft, potentially damaging the transplanted corneal endothelium. Intraoperatively, the risk of this is minimized by use of acetylcholine after IOL placement. Despite this theoretical concern, Chaurasia et al. showed in a large retrospective study (n = 492 eyes) that endothelial cell loss was not significantly increased in a DMEK triple group compared to a group that underwent DMEK alone.[6]

Disadvantages of the LAL itself include the number of postoperative visits necessary while performing DLDD light treatments and lock-ins. The patient must also wear UV filtering sunglasses for the duration of the adjustment period until final lock-in is complete, a process that could last up to two months. Finally, the LAL will come with added out-of-pocket expense for the patient similar to other premium lens options currently available. These are modest inconveniences for the tradeoff of a consistently fine-tuned and customizable refraction. There remain unanswered questions regarding the DMEK plus LAL triple including the optimization and influence of the gas bubble on the light adjustment dynamics.

To the authors' knowledge, the reported DMEK plus LAL triple procedures are the first of their kind worldwide. The LAL could potentially solve many of the existing challenges associated with the DMEK triple. The cornea has adequate time to stabilize post-operatively while spherical and cylindrical refraction is fine tuned. LAL also allows for a degree of flexibility postoperatively, as demonstrated by our Patient A who chose to forgo the initially planned monovision and instead target distance binocularly. Although larger studies with longer follow up are needed to assess the generalizability of our results, these initial cases show the potential benefit of a LAL in enhancing DMEK triple procedure results. The post-operative customizability of the LAL allows for the achievement of excellent refractive outcomes in DMEK triple procedures, including in eyes with significant astigmatism.

Patient consent

This article was created in compliance with the provisions of the Health Insurance Portability and Accountability Act. Consent was not obtained from individual patients because no personally identifying information is included in the presented cases.

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Declaration of competing InterestCOI

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Authorship

All authors attest that they meet the current ICMJE criteria for authorship.

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