Case Report
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Light adjustable lens in a post-lasik patient

Abstract

The Light Adjustable Lens is a newly approved lens that can be altered in-vivo after cataract surgery to address residual refractive error. This is done through highly specific ultraviolet light applications two weeks post-operatively. Patients require 2-5 total light adjustments. The ability to adjust the lens allows patients to more confidently participate in the surgical process while customizing their refractive status. Patients who have previously undergone corneal refractive surgery can provide an added challenge to cataract surgeons. Because of induced changes in corneal structure, intraocular lens calculations can be more difficult, ultimately leading to variability in refractive outcome. The light adjustable lens is sure to change how surgeons and optometrists counsel and manage patients pre- and post-operatively. The case described below details the structure and functionality of the light adjustable lens as well as a clinical application in a post-LASIK patient.

Keywords: light adjustable lens, iol, cataract surgery, intraocular lens, lasik, extended depth of focus

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Introduction

Cataract surgery has evolved significantly over the course of the last century. What was once a relatively invasive procedure has become routine. Since the introduction of the first intraocular lens (IOL) in 1949,[1] IOL technology has advanced in an attempt to achieve refractive perfection. Patient goals have also evolved- visual precision and spectacle independence are now the Holy Grail. In 2017, the FDA approved the Light Adjustable Lens (RxSight, Aliso Viejo, CA)- a three-piece silicone IOL that can be adjusted after implantation by using targeted ultraviolet light through a dilated pupil.[2] Patients who have previously undergone laser assisted in situ keratomileusis (LASIK) are often more challenging for cataract surgeons. There is no perfect method to calculate IOL power; however modern formulas have improved IOL power accuracy significantly. Particularly, in the post-LASIK patient, IOL calculations are more unreliable due to under- or over-estimation depending on the type of LASIK treatment. There are a few main culprits of refractive surprises: errors in corneal measurements attributed to the assumption of refractive index, and the change in the relationship between the anterior and posterior surface of the cornea. Additionally, modern diagnostic equipment can miscalculate anterior chamber depth, which is a key variable in modern IOL formulas.[3–5] Ultimately any error in pre-surgical calculation leads to a change in the effective lens position (ELP), which is the relative position of the IOL with respect to the cornea and retina. Patients who have previously undergone refractive surgery present typically with an expectation of remaining spectacle independent- explaining refractive surprises due to miscalculation can be extremely difficult or uncomfortable.

The light adjustable lens (LAL) has proven to be a valuable tool for surgeons to address residual refractive error. The lens is implanted through clear corneal incision into the posterior capsule in a typical manner. The difference between the light adjustable lens and other IOL's comes two weeks after surgery. The healing process is largely variable from patient to patient and has significant influence on ELP. After refraction is determined to be stable (roughly 2-3 weeks post-operatively) the light delivery device (LDD) is used to apply ultraviolet (UV) light directly onto the anterior surface of the LAL through a dilated pupil. The lens is composed of UV activated macromers suspended in a silicon matrix which migrate and polymerize when exposed to UV light, causing a shift in shape and power of the IOL.[6,7] Because there is no effective way to quantify environmental UV light for each patient, patients are required to wear UV protective glasses during all waking hours in order to keep the lens macromers from prematurely polymerizing. Patients require 2-5 treatments to fully exhaust all macromers and effectively "lock-in" the lens shape. As a bonus, during treatments a small amount of negative spherical aberration can be added (typically to the non-dominant eye) to increase the depth of focus. This allows for maximum distance acuity with functional vision at near for most patients without any undesirable dysphotopsia. The LDD has capability to correct residual refractive cylinder -0.75 to -2.00 DC and sphere -2.00 to +2.00 DS.[7]

Case report

October 7th, 2020 - initial visit

A 59-year-old white male presented to the optometry clinic as a new patient with a complaint of worsening vision in his right eye. He denied any pain or ocular discomfort aside from mild foreign body sensation in the morning. He reported having LASIK in both eyes in the late 1990's with a reported plano target. He had recently undergone photorefractive keratectomy (PRK) enhancement in his right eye to induce myopia with hopes of improving near vision. He also reported a history of dry eye that was self-managed with artificial tears as needed. He had previously used Restasis (cyclosporine 0.05%) BID OU and Xiidra (lifitegrast 5%) BID OU with minimal subjective improvement. This patient had a history of both neck and hip surgery over ten years ago. He was taking no medications aside from a multivitamin and fish oil. He was not a smoker and had family history of cataracts however no known history of any other ocular or systemic pathology.

Initial pre-examination differential diagnoses based on chief complaint:

a) Corneal ectasia secondary to previous corneal refractive surgery

b) Visually significant cataract

c) Ocular surface disease

d) Unspecified macular pathology

Based on complaints and ocular history, it was hypothesized that his complaint of visual decline in his right eye was likely related to his multiple corneal refractive procedures. The first differential diagnosis that was considered was corneal ectasia. Ectasia should be on the differential list for patients who have previously undergone refractive surgery and have complaints of visual change. There are several risk factors that would lead to an increased likelihood of ectasia. These risk factors include deep ablation, forme fruste keratoconus, steep corneas, or thin corneas (<500 microns).[8] As this was a new patient to our clinic, his corneal health was unknown prior to his examination. He did note two separate procedures on his right eye so it was fully possible that there was a significant cumulative ablation. A corneal topography was completed and revealed a topographical pattern consistent with prior laser vision correction. No extreme thinning was noted, nor was any significant irregular astigmatism (Figure 1 & 2). Central corneal thickness was 511 microns and 532 microns in the right and left eye respectively. The topographical pattern was symmetrical across the corneal apex and there were not isolated areas of posterior thinning. The central cornea of each eye was relatively flat compared to the periphery which is consistent with myopic laser vision correction. Macular pathology also was to be ruled out. There were no complaints of distortion or central vision loss, nor was there any noted history of retinal disease or systemic disease typically associated to retinal pathology. Nonetheless, a macular optical coherence tomography scan (OCT) was completed prior to examination and revealed unremarkable anatomy (Figure 3). A normal foveal contour was noted with no sign of retinal pigment epithelium disease, macular edema, or thinning in both eyes.

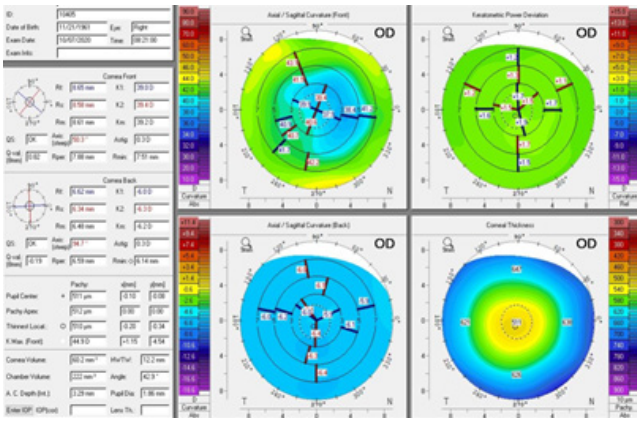

Figure 1 No extreme thinning was noted, nor was any significant irregular astigmatism.

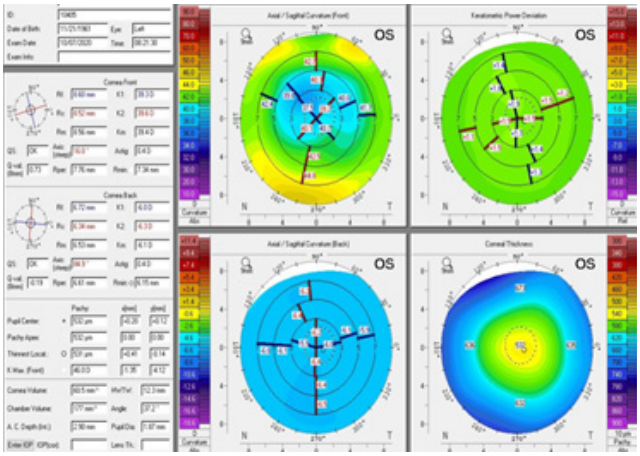

Figure 2 No extreme thinning was noted, nor was any significant irregular astigmatism.

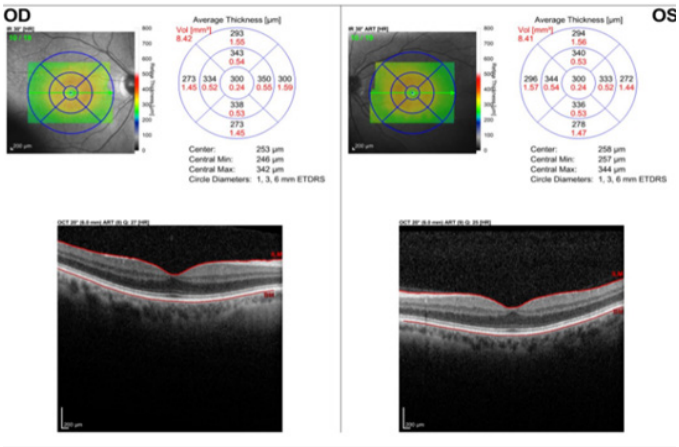

Figure 3 A macular optical coherence tomography scan (OCT).

Knowing the cornea and macula anatomically were unremarkable, the main differential diagnoses that remained were significant ocular surface disease and/or visually significant cataract. This patient was relatively young for cataracts however he did spend most of his time in southern Florida. Ultraviolet sun exposure is linked to the development of cortical cataracts in particular[9] and cortical lenticular change can significantly and quickly lead to visual decline. For these reasons, visually significant cataract was the leading differential diagnosis heading into ocular examination. On examination, uncorrected distance visual acuity was 20/125 (pinhole to 20/50-1) OD and 20/15-OS. His manifest refraction in his right eye was -5.50 DS correctable to 20/30-2, and +0.50 - 1.00 x 098 correctable to 20/15-1 in his left eye. Pupils reacted swiftly with no sign of APD in either eye. Confrontational fields were full OU, and he displayed full range of motion on extraocular muscle testing. Both eyes were ortho on cover test. It is well known that prior corneal surgery can exacerbate ocular surface disease and its related symptoms. This patient had a history of dry eye symptoms that were minimally improved with over-the-counter artificial tears and prescription topical medications. He noted that the change in his vision had not corresponded to a subjective worsening of dry eye symptoms. On slit lamp examination, mild meibomian gland dysfunction was noted on both lower lids. Central corneas were clear with faint peripheral LASIK scarring without any evident haze. Anterior chambers were deep and quiet OU. His right eye showed significant lenticular changes of 2+ nuclear sclerosis with 2+ cortical and 2+ posterior subcapsular cataracts. The left eye also showed 2+ nuclear sclerosis. 1 drop containing fluorescein sodium 0.25% and benoxinate hydrochloride 0.4% was used to measure intraocular pressure (IOP) by goldmann applanation tonometry. IOP was measured at 13 OU. Minimal staining of the cornea was noted following goldmann applanation tonometry and tear film appeared to be adequate. The patient was dilated using one drop of 1% Tropicamide and one drop of 2.5% Phenylephrine. Both pupils dilated to a diameter of 7mm using a 20D and 90D lens, the posterior segment was examined with a binocular indirect ophthalmoscope and slit lamp. The vitreous was clear. The optic nerve cup to disc ratio was measured as 0.2 OD and 0.15 OS. Vessels in each eye were normal caliber. Both maculas were both flat with a positive foveal reflex. Both retinas were attached 360 degrees with no sign of any tears or pathology.

It was concluded that the patient's visual complaints were due to significant lenticular changes. A cataract surgeon was consulted on this day, and it was determined that the plan was to proceed with cataract surgery on only his right eye with plan to re-evaluate the left eye in the future. A-scan biometry provided measurements to properly calculate

IOL power. A detailed discussion took place regarding visual goals and IOL options. The patient was comfortable with his distance vision in his left eye and had a goal of maintaining functional near vision with his right. Most important to him was staying out of glasses for distance while limiting glare at night. Various IOL's were discussed including a trifocal Panoptix (Alcon, Ft. Worth, TX) or extended depth of focus Symfony (Johnson & Johnson, Jacksonville, FL). The patient was advised that due to his previous LVC, there was a higher likelihood of refractive inaccuracy. Because of this and his desire for refractive precision, it was determined that an adjustable monofocal IOL would be the best choice. The planned IOL would be the LAL with an initial target of plano. It was discussed with the patient that the target could be adjusted during post-op light adjustments to match his natural working distance.

November 2, 2020 - cataract extraction and IOL implantation OD

Surgery was completed without complication by the consulting ophthalmologist from the patient's initial visit. The natural lens was removed using phacoemulsification in the typical fashion through a temporal clear corneal incision. A +23.00 D Light Adjustable Lens was implanted into the posterior capsule. The patient was placed on a combination drop of Prednisolone 1% /Gatifloxacin 0.5%/Bromfenac 0.075% to be used TID for three weeks in the operated eye. The patient was provided UV protective glasses to be worn during all waking hours and instructed to report to the optometry clinic the next day for follow-up

November 3, 2020 - day one post op exam OD

The patient reported for follow-up as scheduled with the authoring optometrist. Uncorrected visual acuity was 20/20-2 in the operated eye. IOP using goldmann applanation was measured to be 15 mmHg. The cornea was clear aside from previously noted LASIK scars. There was evidence of trace cell in the anterior chamber. The IOL was clear and centered in the posterior capsule. The patient was reminded to maintain his drop regimen as directed by the surgeon while continuing to wear his UV glasses and instructed to report for follow-up in one week.

November 10, 2020 - week one post op exam OD

The patient presented for follow-up as scheduled with the authoring optometrist. Uncorrected visual acuity in the operated eye was 20/20 one week after surgery. IOP using goldmann applanation was measured as 15 mmHg. Cornea was clear aside from previously noted LASIK scars. The anterior chamber was deep and quiet and the IOL was centered and clear. The patient was using his postoperative drops as directed three times daily. The patient was encouraged to use preservative-free artificial tears throughout the day in order to optimize the tear film in preparation for light adjustments. At this visit, the patient reported a significant improvement of his vision in his right eye. He stated he was now more aware of diminished visual quality in his left eye including increased halos and glaring at night. The original surgeon was again consulted, and the patient elected to schedule surgery on his left eye which would be set for the following week. Biometry from the original October 7th visit was used in IOL calculations for the left eye. Again, the plan would be LAL with an initial plano target.

November 16, 2020 - cataract extraction and IOL implantation OS

Surgery was performed by the original consulting ophthalmologist and again proceeded without complication. The natural lens was removed using phacoemulsification in the typical fashion through a temporal clear corneal incision. A +21.50 D Light Adjustable Lens was implanted into the posterior capsule. The patient again was placed on a combination drop of Prednisolone 1%/ Gatifloxacin 0.5%/ Bromfenac 0.075% to be used TID for three weeks in the operated eye. The patient was instructed to report to the optometry clinic the next day for follow-up.

November 17th, 2020 - day one post op exam OS

The patient reported to the optometry clinic with an uncorrected VA of 20/30-2 in the operated eye. IOP using goldmann applanation was measured as 17 mmHg. The cornea was clear aside from previously noted LASIK scars. There was evidence of trace cell in the anterior chamber. The IOL was centered and clear. The patient was instructed to report for follow-up in one week.

November 23, 2020 - 3-week post-op OD / 1-week post-op OS

Seven days after the second surgery, the patient reported to the optometry clinic with a noticeable decline in visual quality in his right eye. Uncorrected visual acuity was 20/20-2 OD and 20/25+2 OS. Autorefractor on this day yielded +1.25 - 0.75 x 049 in the right eye and +1.00 + 0.50 x 004 in the left. The right cornea was clear, the chamber was quiet, and IOL was centered. 2+ Posterior capsular opacification was noted in the right eye which was determined to be the cause of his complaint. The patient was referred back to the surgeon for evaluation and posterior capsulotomy.

November 24th, 2020 - neodymium-doped yttrium aluminum garnet (Nd:YAG) capsulotomy OD

The patient presented to the ophthalmology clinic for evaluation with the original surgeon. Uncorrected visual acuity of the right eye was 20/20-2. The patient was dilated with Tropicamide 1%. Once adequate dilation was achieved, one drop of Proparacaine 0.5% and one drop of Combigan (Brimonidine Tartrate 0.2% / Timolol Maleate 0.5%) were instilled. The patient was brought to the laser and a capsulotomy was performed in a circular pattern. There were no complications. The IOP was measured as 17 mmHg immediately following the procedure. The patient was instructed to return for the first light adjustment with the authoring optometrist in one week.

November 30, 2020 - light adjustment #1 OU

The patient returned to the optometry clinic one week after posterior capsulotomy on his right eye (four weeks s/p PCIOL OD and two weeks s/p PCIOL OS) for first light treatment. The first light treatment and all subsequent light treatments would be performed by the authoring optometrist. Uncorrected DVA was 20/25-1 OD and 20/25-2 OS. The patient's manifest refraction was +1.25 - 1.00 x 129 and +1.00 DS OD and OS respectively. Both eyes were correctable to 20/15. After a detailed discussion regarding visual goals, the patient elected to proceed with light adjustment with plano target OU. The patient was dilated using a drop of Tropicamide 1% and Phenylephrine 10%. Once adequate dilation of 7mm was achieved in both eyes, the patient was brought to the light delivery device (LDD) in a separate darkened room where UV light exposure could be limited. One drop of Proparacaine 0.5% was instilled OU. The left eye was patched to prevent inadvertent UV exposure while a gonioscopy style contact lens with lubricant gel was placed on the right eye. The lens was centered in the device oculars, and UV light was applied directly to the IOL through the dilated pupil in a pattern calculated by the LDD computer. The duration of treatment is also determined by the LDD computer. After full treatment, the same procedure was repeated

for the left eye. The patient was reminded to continue wearing his provided UV glasses and encouraged to use artificial tears QID OU.

December 2, 2020 - Nd:YAG OS

The patient returned two days later for the second scheduled light adjustment. Uncorrected distance visual acuity was 20/15+2 OD and 20/15 OS while uncorrected near visual acuity was J7 OD and J7 OS. Binocular visual acuity was 20/10-2 and J7. Manifest refraction was Plano DS OD and +0.50 DS OS. Both corneas were clear, chambers were deep and quiet, and IOLs were centered. The posterior capsule was open in the right eye, however 1-2 posterior capsular haze had developed on the left eye. Even with 20/15 uncorrected vision in the eye, the patient had complaints of significant glare at night that had worsened since his previous light adjustment. The surgeon was consulted at this time, and it was decided to perform a YAG posterior capsulotomy on the left eye that afternoon. This proceeded without complication in accordance with the same procedure described above. The patient was then instructed to return for subsequent light adjustment in two days.

December 4, 2020 - light adjustment #2 OU

The patient returned for his second light treatment to be performed by the authoring optometrist. Uncorrected distance visual acuity was 20/15-1 OD and 20/20+2 OS. Near visual acuity was J3 OD and J3 OS. Manifest refraction was Plano + 0.50 x 101 in his right eye and +0.50 DS in his left eye, both correctable to 20/15. The patient decided to proceed as previously planned with the second light adjustment with a plano target in both eyes. The second light adjustment proceeded in the same fashion as the first. One drop of Tropicamide 1% and Phenylephrine 10% was used to maximally dilated each pupil. Each eye was treated at the LDD using a contact lens and lubricant gel. Following the treatments, the patient was reminded to continue wearing his provided UV glasses and encouraged to use artificial tears QID OU.

December 9, 2020 - light adjustment #3 OU

The patient reported as directed for his scheduled third light adjustment with the authoring optometrist. Distance visual acuity was 20/15-2 OD and 20/20+2 OS. Near visual acuity was J2 OD and J3 OS. Binocularly he maintained 20/15-1 acuity at distance and J2 at near. His manifest refraction was -0.25 + 0.50 x 106 in his right eye and -0.50 + 0.75 x 008 in his left eye, both correctable to 20/15. The patient at this point was presented with a choice- either the lock-in process could be initiated which would polymerize all remaining macromers and effectively lock the refractive state of the lens; or he could elect to treat the slight residual refractive error in one or both eyes in an attempt to achieve a true plano endpoint. The patient decided that he was content with his binocular vision and elected to forgo the final treatment. Once adequate dilation was achieved with one drop of Tropicamide 1% and Phenylephrine 10%, each eye was treated individually with a contact lens. The lock-in procedure is essentially the same as the previous adjustments, however during lock-in, a broad beam of UV light is directed on the lens (as opposed to patterned light). This is meant to exhaust all macromers at once, thereby not inducing refractive change. The duration of the treatment again is calculated by the LDD computer. Following completion of each treatment, the patient was again reminded to continue wearing his provided UV glasses while using artificial tears to maintain tear film integrity. The lock-in process in this case was split into two visits in order to minimize direct UV exposure. The final lock-in would be scheduled for two days later.

December 11, 2020 - light adjustment #4 OU (final lock-in)

The patient returned as scheduled for his final lock-in light treatment with the authoring optometrist. Distance visual acuity was 20/15 OD and 20/20 OS. Near Visual acuity was J5 OD and J2 OS. Manifest refraction was -0.25+0.50x114 OD and -0.75+0.75x179 OS. Once maximum dilation was achieved with Tropicamide 1% and Phenylephrine 10%, each eye was treated individually using a contact lens in the previously described method. The patient was instructed to continue wearing his provided UV glasses for 24 hours. A follow-up was scheduled for 3 months.

March 21, 2021 - final follow-up

At the scheduled follow-up, the patient reported comfortable distance and near vision. He noted mild dryness which had worsened since he returned to Wisconsin from his winter home in Florida. Additionally, he noted a slight increase in floaters in his right eye, however these had decreased over the past two months. No other ocular symptoms were reported. Uncorrected distance visual acuity was 20/20 OD and 20/25 OS. Near visual acuity was J7 OD and J2 OS. Binocular visual acuity was 20/15-2 and J2. Manifest refraction was Plano DS in the right eye and -0.75 DS in the left. IOP was measured as 15 OU. Pupils were equal and round with no sign of APD. Motility was full, as were confrontational fields in both eyes. Mild meibomian gland dysfunction (MGD) was noted on each lower lid. Corneas were each clear aside from previously noted LASIK scars. There was no fluorescein staining evident. Anterior chambers were each deep and quiet. Irises were flat, and both IOLs were centered with open posterior capsules. The patient was dilated with Tropicamide 1%. On dilated fundoscopic exam, optic nerves exhibited healthy rims with cup to disc ratios of 0.2 and 0.15 OD and OS respectively. Vitreous syneresis was noted in the right eye with no evidence of cell or pigment. A Weiss ring also was not noted. Vitreous was clear in the left eye. Vessel caliber was normal in both eyes. Both maculas were flat, and each retina was flat and attached 360 degrees. It was recommended that the patient start basic lid hygiene and hot compresses for mildly symptomatic MGD while continuing artificial tears TID-QID. Signs and symptoms of retinal tears and detachments were also discussed, and the patient was instructed to return immediately if he noted any flashes, floaters, or loss of vision. The patient left the optometry clinic satisfied with his vision and would schedule a comprehensive exam in one year.

Discussion

LASIK was first approved by the FDA in 1999 in the United States. Lifestyle and a desire for spectacle independence is often the driving force to pursue refractive surgery. LASIK saw increasing popularity in the late 1990s through early 2000's and has proven to be reliable with more than 95% of patients satisfied with their vision after the procedure.[10] The cornea provides roughly two thirds of the dioptric power of the human eye while the lens provides the remaining one third. Unlike the cornea, which is relatively stable by early adulthood, the lens changes later in life which often contributes to visual decline. The average age for LASIK patients in 2002 was 41.[11] Fast forward two decades, the same patients that were among the first to undergo LASIK are now experiencing visual symptoms attributable to emerging presbyopia and the development of cataracts. With early generation diagnostic equipment, patients who had undergone LASIK 20+ years ago are more likely to have residual refractive error that may have previously been masked by fully functional accommodative systems. With increasing age, studies have found there is higher likelihood

for laser retreatment,[12] presumably due in part to lenticular changes causing refractive shift. Naturally, there is higher expectation for refractive accuracy in post-LASIK patients. Often patients that have experienced full spectacle independence find it difficult to understand why there would be a need for corrective lenses after cataract surgery.

There are multiple reasons why IOL calculations can be difficult in this patient population. First, a large assumption is the assigned index of refraction of the cornea (1.3375). Corneal mapping devices rely on principles of anterior corneal curvature to derive dioptric power. In order to do this, it is assumed that the ratio of curvature between the anterior and posterior cornea is constant. With LASIK and other LVC procedures, however, the anterior cornea is altered while the posterior cornea is unaltered, therefore the ratio is changed, influencing calculation. The second reason calculations can be unreliable involves the fact that corneal mapping instruments assume proportional corneal curvature between the central and peripheral cornea. With LVC, the central corneal curvature is altered while the peripheral cornea remains untouched. This change in asphericity can induce change in calculated ELP. Most often, miscalculations in lens power lead to residual hyperopia in myopic LASIK patients and myopia in hyperopic LASIK patients.[5–7]

Unfortunately, refractive surprises after cataract surgery are not an uncommon occurrence in patients who have previously undergone refractive surgery. There are a few options for addressing residual refractive error after cataract surgery, each with their own pros and cons. One option is to repeat LVC - either LASIK or PRK. This, however, may not be an option for patients with insufficient corneal thickness, irregular topographies, or symptoms attributable to ocular surface disease. A second option would be to do a complete IOL exchange. This comes with obvious risks and is best done early in the postoperative period before the capsule has tightened. A piggyback lens could be considered as well, however like IOL exchange, comes with natural inherent risk. The idea of an IOL that could be manipulated postoperatively is not new, with first introduction in 1996 by way of an inflatable compartment in a three-piece IOL. This has proven to be less than ideal as the inflation procedure is invasive while only correcting spherical error.[13,14]

The current LAL technology was introduced by Danial Schwartz, MD in 2003.[14] The LAL is a three-piece foldable silicone lens with modified C haptics that relies on properties of photochemistry and physics. The lens is composed of a silicon matrix with a photoreactive macromer as well as UV absorbers that protect the retina during light adjustments. The macromers that are exposed to UV light (wavelength 365 nm) aggregate and polymerize which alters the shape of the lens. During treatment, the UV light is emitted in a very particular pattern to induce changes in refractive status. For instance, to correct hyperopia, the center portion of the IOL is irradiated; whereas to correct myopia, the peripheral lens is irradiated. After desired adjustment has been achieved, the lens must be locked in to prevent further polymerization and subsequent power change. The lock-in process involves a broad beam of UV light, polymerizing all remaining macromers.

The LAL has an aspheric design which is intended to offset higher order aberrations of the cornea. It also has a small amount of built-in negative spherical aberration that adds extended depth of focus (EDOF). The lens in its normal state has a small level of aberration however this can be manipulated depending on individual patient goals to increase visual range. Spherical aberration is when light rays on the optical axis focus at a different point than paraxial rays. Specifically in negative spherical aberration, central axial rays converge before paraxial rays. This creates an area of defocus which acts to extend the range of near vision. Often, spherical aberration along with other higher order aberrations are undesirable as they create dysphotopsias or "optical noise" in a visual system. The LAL, however, incorporates enough to be advantageous without being counterproductive. The light treatment process is relatively simple and noninvasive. Patients are first refracted under photopic conditions. Once precise refraction is determined patients are dilated generally with a combination of 1% tropicamide and 2.5% or 10% phenylephrine. In order to proceed with light adjustment, the entire circumference of the IOL must be visible through the dilated pupil (minimum 6 mm diameter). The light delivery device (LDD) is composed of a biomicroscope with an optic projection system capable of emitting UV light. The patient is positioned appropriately and after a drop of 0.5% proparacaine, a contact lens is placed on the cornea (with the aid of lubricant gel). The treatments last anywhere from 41-130 seconds. After treatments patients experience mild blurred vision for a few hours due to dilation and corneal surface disruption from the contact lens. It is also not uncommon to experience temporary erythropsia. Patients require 1-3 adjustments followed by 1-2 lock-in treatments.

The above case details the dynamic nature and predictability of the LAL. The patient changed his refractive target three individual times. He initially selected a "mini-monovision" end refractive outcome: OD -0.50 DS, OS: Plano, with goals of best possible distance vision and functional near. After both eyes were implanted, he changed his mind and elected for bilateral plano outcomes. After the second adjustment and his left eye had been overcorrected, he found he was happy with his refractive state and decided to forgo further treatment ultimately ending with final refraction of Plano DS and -0.75 DS, OD and OS respectively. The unaided visual acuities are also somewhat surprising for a lens that truly is monofocal. Although it does have a low amount of EDOF, there is no diffractive mechanism at play. Therefore, optical integrity of the lens remains high allowing for maximum subjective visual quality. This case also illustrates relative stability as no significant refractive shift was noted several months after final lock-in. The LAL does provide some logistical barriers for patients. First, there is the obvious need for multiple post op visits to complete the light adjustments. Second, heavy emphasis must be placed on patient compliance during the entirety of the postoperative period. Because the LAL can be affected by simple environmental UV light, patients are required to wear UV protective glasses that have been vetted by the IOL manufacturer to provide adequate UV coverage. Without the added protection, the macromers in the LAL would be likely to polymerize prematurely which may require explantation of the lens in worst case scenarios. Patients are required to wear the provided UV glasses during all waking hours until 24 hours after final lock-in. Fortunately, the latest version of the LAL includes an added UV coating which would reduce the need for UV glasses, however this was not available when this patient underwent his surgeries and subsequent treatments.

This technology suggests that there soon may be a paradigm shift towards bilateral sequential surgery. Aside from financial reasons, there are two traditional arguments for delayed sequential surgery: endophthalmitis risk and refractive targeting. A large study conducted between 2013 and 2015 found there was no associated decline in post-op VA or refractive outcome, nor was there any significant added risk of complication.[15] Common practice also is to allow 1-2 weeks between surgeries. This allows time to change IOL power in the event of a refractive surprise on the first eye or if patients changed their mind based on first eye outcome. With the LAL, both eyes are adjusted postoperatively so there is no refractive advantage to delayed sequential surgery.[16] Even with logistical barriers, the LAL

has demonstrated stability and precision. A 2018 study concluded that 72.7% of patients electing standard monofocal IOLs experienced refractive outcomes within 0.50 DS of target within 60 days post-op. The LAL shows outcomes within 0.50 DS 92.1% 6 months post-op.[8,17] Advanced technology IOLs (multifocal and EDOF IOLs specifically), are generally reserved for patients with pristine retinal health and uncompromised corneas. Because the LAL is monofocal, patients with mild AMD or corneal pathology can be considered candidates. With the LAL, refractive precision is a much more common reality than previous generation IOLs. Proper education and open discussion between patient, optometrist, and surgeon are key.

Conclusion

Because of the somewhat unpredictable outcomes and large assumptions made by modern IOL calculations, the LAL has proven to be a valuable tool for precision planning. The lens has a relatively large range that is useful in displaying various scenarios (i.e., mono-vision, bilateral myopic or plano targets, etc.) to patients in real time. This case displays the dynamic nature of the LAL and how the process can be individually customized. Patient education is imperative during the pre-operative counseling process as it is essential that patients comply with all post-operative protocols. If non-compliance with the provided UV spectacles or inability to maintain post op appointments is of concern, an alternative IOL should be considered. Even though this lens is optically monofocal, patients often experience an extended range of comfortable vision with little to no dysphotopsias. Most importantly, the refractive outcomes with the LAL have proven to be stable and predictable, yielding a high level of patient satisfaction especially in post-LVC patients.

Acknowledgments

None.

Conflicts of interest

The author declares that there are no conflicts of interest.

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