Top 5 Pearls to Consider When Implanting Advanced Technology IOLs in Patients With Unusual Circumstances

Zale D. Mednick, BA
Guillermo Rocha, MD, FRCSC

Pearl #1: The Use of a Toric Multifocal Intraocular Lens (IOL) in the Management of Hyperopic Astigmatism

Background

The mainstay of treatment for those with hyperopic astigmatism who wish to bypass the need for glasses or contacts has traditionally been laser treatment. Both hyperopic laser in situ keratomileusis (LASIK) and photorefractive keratotomy (PRK) have been used to correct hyperopic astigmatism.

Although LASIK can provide promising results for a portion of patients with hyperopic eyes, it becomes less effective when dealing with more exaggerated degrees of hyperopia. Refractive results are much more successful for low diopter (D) hyperopia, with a drop in efficacy starting at + 4.00 to + 5.00 D.[1] Esquenazi and Mendoza[2] reported that when LASIK is performed on eyes with >5.00 D of hyperopia, both the safety profile of the procedure and the refractive outcomes dramatically decline, coinciding with decreased corrected distance visual acuity (CDVA). Choi and Wilson[3] echoed this notion, citing a 2-line drop in CDVA when LASIK was used to treat hyperopia of 5.00 to 8.75 D. This is in stark contrast to the results achieved by LASIK to improve myopia, where corrections are feasible for a far greater range of refractions.

Part of the reason that hyperopia is less amenable to correction of higher diopter errors may owe to the fact that larger ablation zones are needed to achieve better refractive results.[4] The optimal size of the ablation zone for hyperopic LASIK is >5.5 mm,[1] and as such, more corneal alteration is required.

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PRK is another laser option for treating hyperopia, although the same problem as LASIK exists. Beyond + 4.00 D, the efficacy of hyperopic PRK is decreased.[5] When compared with LASIK, PRK has a slower refractive stabilization. Refractive stability for LASIK is generally achieved at 1 month, compared with 6 months for PRK.[6]

Considering the pitfalls that laser techniques present when attempting to correct uncomplicated hyperopia, it is not surprising that there are further challenges when using LASIK to correct hyperopic astigmatism. Specifically, laser procedures have had limited success in correcting cylinder in this setting. A study by Francesconi et al[7] examined the efficacy of LASIK in correcting radial keratotomy-induced hyperopia. A subanalysis of the group that underwent LASIK for hyperopic astigmatism showed a cylinder change from $+ 0.87 \pm 0.92$ to only $+ 0.75 \pm 1.03$ D. Ibrahim[8] showed that in a group of hyperopic patients, LASIK was only able to reduce astigmatism from a cylinder of + 2.75 to + 1.25 D. Arbelaez and Knorz[9] were also able to demonstrate that LASIK is less effective in hyperopic astigmatism than for pure hyperopia.

Barraquer and Gutierrez[10] suggested better results, with 90% of compound hyperopic astigmatic eyes achieving a cylinder within 1.00 D of emmetropia post-LASIK. Argento and colleagues (1997) showed similar results, with a postoperative mean refractive cylinder of $+ 0.58 \pm 1.22$ D in patients with simple hyperopic astigmatism and $+ 0.12 \pm 1.23$ D in those with compound hyperopic astigmatism (CHA). A total of 66.7% in the simple hyperopic astigmatism group and 60.4% in the CHA group achieved uncorrected distance visual acuities (UDVAs) of 20/20 or 20/25.[11] Such UDVA is less impressive when compared with the results of LASIK for myopic astigmatism. In a 5-year study of patients undergoing LASIK for myopic astigmatism, 85% achieved a UDVA better than 0.0, and 94% achieved a UDVA better than 0.2.[12] This highlights the reality that laser procedures for hyperopic astigmatism still leave much to be desired.

As laser treatments have not produced ideal results in the management of hyperopic astigmatism, several approaches involving IOL implantation have been described. The following case illustrates the use of a toric multifocal IOL in a patient who sought correction of his hyperopic astigmatism.

Case—Unilateral Hyperopic Astigmatism

A 23-year-old white male presented in July 2010 with a diagnosis of CHA in the right eye, associated with iris coloboma. This patient was seeking a refractive balance, as his left eye was 20/16 uncorrected. The right eye had a correction of $+ 3.25 + 2.25 \times 65$ that gave him a vision of 20/25. With-the-rule regular astigmatism was evident on videokeratoscopy (Fig. 1). There was an inferior coloboma and the lens equator

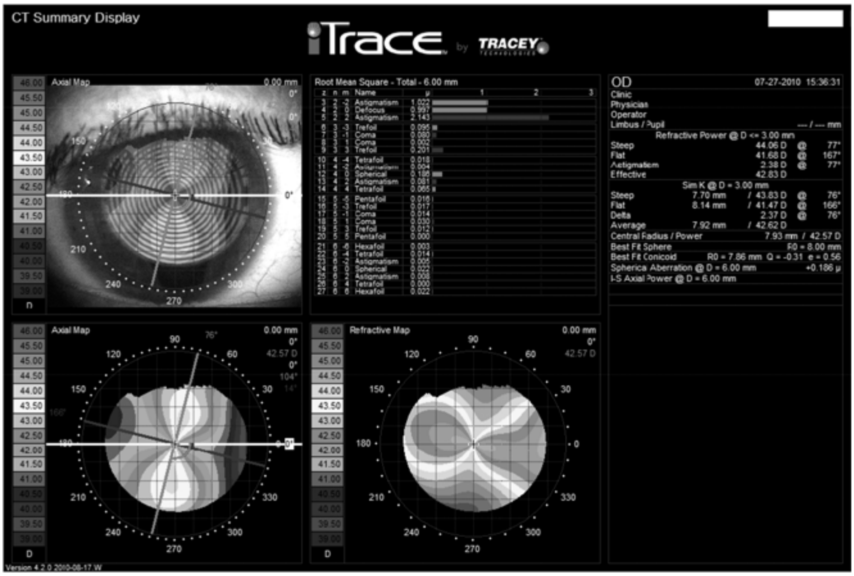


Figure 1. *Pearl #1: The use of a toric multifocal intraocular lens in the management of hyperopic astigmatism. iTrace videokeratoscopy displaying regular with-the-rule astigmatism.*

inferiorly could be appreciated as having a small notch. There was no phacodonesis, and the zonules were present.

Several options were discussed, and in the end, a toric multifocal IOL implant was considered, along with a pupilloplasty. Surgery was performed in February 2011. The calculation for the right IOL implant was made through the http://www.rayner.com website. An M-Flex T + 3 lens, catalogue number 588FPRM, with a power of +29.00/+3.00 cylinder was considered. This in essence also produced an addition of + 3 D. The surgery was performed using a standard phacoemulsification technique and was uneventful. The orientation of the lens was at 78 degrees. After completion of the surgery, viscoelastic was placed in the anterior chamber after Miochol injection. The pupil constricted partially from the superior portion, but the inferior coloboma was obviously opened. Two 10-0 prolene sutures were passed using an SC-5 needle and tied using the Siepser slip knot technique. At the end of the procedure, the pupil looked significantly more round.

On follow-up examinations, uncorrected vision at last visit was 20/25. The refraction was $-1.00 + 0.50 \times 50$. The patient was happy, and cosmetically, the pupil was significantly better.

Discussion

Several different lens options have been explored in the management of hyperopic astigmatism. The use of implantable contact lenses

(ICLs) was illustrated in a case report by Kamiya et al.[13] The patient described had sustained a hyperopic astigmatic refraction after LASIK, $+2.25-1.0\times 160$. Corrective surgery involved implantation of the STAAR Implantable Collamer Lens and making limbal-relaxing incisions. The end refraction was $+0.50-0.5\times 165$. The authors cite that a main advantage of this strategy over LASIK is that in thin hyperopic corneas that had previously undergone myopic LASIK, using the ICL and limbal-relaxing incisions, has less associated risk of causing keratectasia when compared with an additional LASIK procedure.

Bartels et al[4] presented a study evaluating the Artisan toric phakic intraocular lens (pIOL) for correcting hyperopic astigmatism. This is an iris-fixated anterior chamber lens. At 6 months, UDVA was at least 20/40 in 76.6% of patients and postoperative astigmatism was 0.19 D at 144 degrees. The drawback, however, of using ICLs in phakic eyes is that without removing the natural lens, there is a greater risk of cataractogenesis and pigment dispersion.[14] Bartels et al[4] comment on the possibility of clear lens extraction, followed by posterior toric IOL implantation. They point out that although this option may be attractive, it comes at the cost of accommodation.

The toric multifocal IOL may represent a novel approach to hyperopic astigmatism. The fact that the lens is multifocal means that even though there is a clear lens extraction, accommodation is not truly sacrificed. Furthermore, performing clear lens extraction avoids the complications of cataractogenesis and pigment dispersion that are associated with ICLs. As laser procedures for hyperopic astigmatism fail to achieve the refractive results that patients have come to expect, perhaps the use of new IOLs may be the appropriate solution.[4]

■ Pearl #2: The Use of a Toric IOL in a Patient With Pellucid Marginal Degeneration (PMD)

Background

Keratoconus and PMD are part of a spectrum of noninflammatory corneal ectasias.[15] Essentially, the condition involves a thinning of the cornea, which results in a steepening of the corneal surface, as it is less able to resist the natural pressure of the aqueous humor. Such steepening can then result in myopic changes, astigmatic refraction, and decreased visual acuity.

A multitude of treatment options exist in the management of keratoconus and PMD. On the less invasive end of treatment, glasses or rigid gas permeable contact lenses may be the first line approaches.[16] In advanced cases, more invasive options may be pursued, such as the insertion of intacs, collagen crosslinking, or even corneal transplant.[17]

In some cases, the most appealing option may be to insert a pIOL or pseudophakic IOL. Some of the parameters affecting the decision to choose this approach involve the rate of progression of the keratoconus, the patient's age, and the presence or absence of cataract. The following case illustrates the use of a toric IOL in a keratoconus patient with cataracts.

Case

A 44–year-old white male presented for consultation for possible refractive surgery. During the course of the examination, an abnormal retinoscopy reflex was detected. Central corneal topographies were within normal limits at 594 and 595 μm for the right and left eye, respectively. His prescription for glasses in the right eye had been stable at $-7.00+2.50\times 8$, which gave him a vision of 20/25+ 2. In the left eye, $-5.00+0.75\times 178$ gave him a vision of 20/30. However, corneal topography revealed inferior corneal steepening and a pattern consistent with PMD. No refractive surgery was offered.

In 2011, this patient was then referred again this time for consideration of cataract surgery. His refraction had remained stable and corneal topography revealed inferior corneal steepening with a "crab-claw" configuration, consistent with PMD in both eyes (Fig. 2). The decision was made to proceed with cataract surgery, and because the prescription had been stable for so many years, toric IOL implantation was performed. Surgery was performed in April 2011 for both eyes. The right eye received an Alcon SN60T3 + 13.0 Dand the left eye received a similar lens after calculation with the Toric IOL calculator online (Fig. 3).

Postoperatively, uncorrected vision was 20/80 on day 1 for the right eye and 20/25 for the left eye. Three months after the surgeries, bilateral UDVA was 20/25.

Discussion

The use of toric pIOLs and IOLs has been reported with relative success in the literature. In noncataractous cases of keratoconus, the pIOL may be an appealing option, especially in cases of high degrees of myopia and astigmatism. The toric ICL in particular may be a good option, as it is available in the spherical range of −3.00 to −23.00 D and can come with a cylinder as high as 6.00 D.[16] Furthermore, this ICL has the advantage of 3-mm incision, compared with the 5.5- to 6-mm incision required for other types of pIOLs.[16] Another unique approach was described by Coskunseven et al,[18] who showed positive results in keratoconus patients with severe myopia who underwent a procedure consisting of combined Intacs and a posterior chamber toric ICL. Some of the risks associated with the pIOL, however, include cataractogensis and increased intraocular pressure.[19]

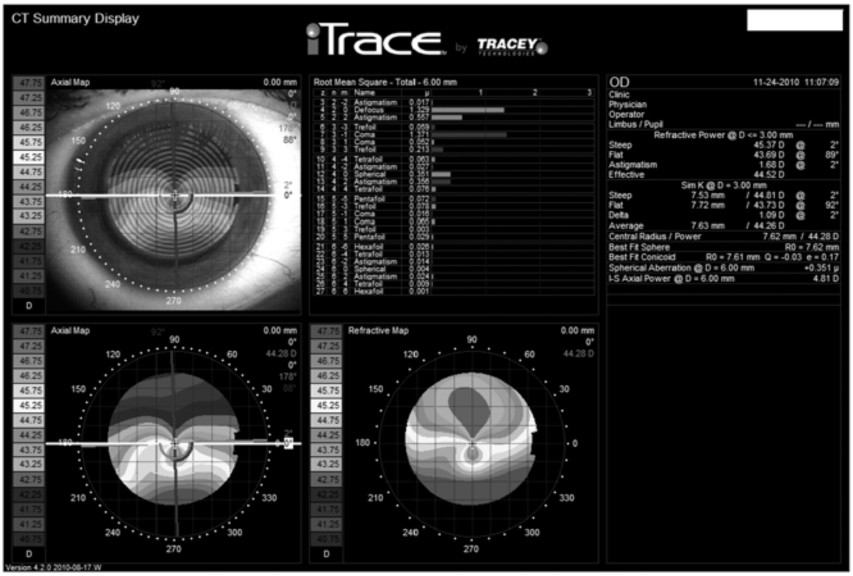
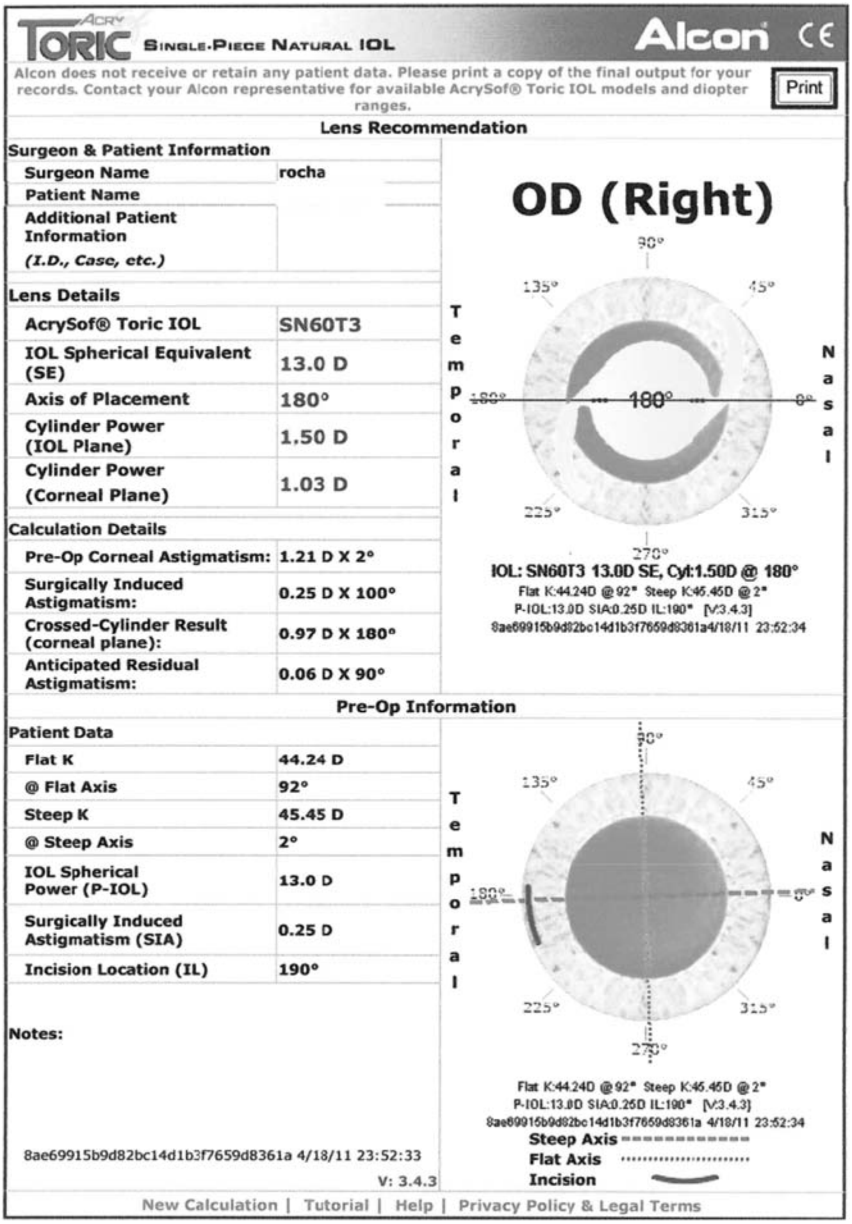


Figure 2. *Pearl #2: The use of a toric intraocular lens in a patient with pellucid marginal degeneration. iTrace videokeratoscopy displaying inferior steepening consistent with pellucid marginal degeneration.*

The use of the pseudophakic IOL, of course, would have more of a role in keratoconus patients who develop cataracts. Although there are no large-scale studies that have investigated the use of pseudophakic toric IOLs in patients with keratoconus, several case studies have been reported in the literature. Visser et al[20] presented 2 cases in which the AcySof toric IOL led to positive results in keratoconus patients with cataracts. Sauder and Jonas[21] reported similar cases of such use of a silicone toric IOL. There are few reports addressing PMD and the use of toric IOLs.

Navas and Suárez[17] reported 2 cases in which pseudophakic toric IOLs were used in patients with forme fruste keratoconus who did not even have cataracts. Thus, the implication is that in the correct patient, the toric IOL may be a suitable management option for keratoconus even if cataract is not present. In the specific cases that they report, the patients were 55 and 46 years old. As the authors explained, because the patients were middle aged and it is quite possible they would have developed cataracts relatively soon, it was more sensible to perform a clear lens extraction and insert a toric IOL, rather than use a pIOL and risk needing a second procedure if a cataract developed in later years.[17]

The key principle when considering the use of a pIOL or IOL for the correction of astigmatism is to ensure that the patient's keratoconus is stable. If the keratoconus is still progressing, as is part of the natural


AcrySof TORIC SINGLE-PIECE NATURAL IOL — Alcon CE

Alcon does not receive or retain any patient data. Please print a copy of the final output for your records. Contact your Alcon representative for available AcrySof® Toric IOL models and diopter ranges. [Print]

Lens Recommendation

Surgeon & Patient Information	
Surgeon Name	rocha
Patient Name	
Additional Patient Information (I.D., Case, etc.)	
Lens Details	
AcrySof® Toric IOL	SN60T3
IOL Spherical Equivalent (SE)	13.0 D
Axis of Placement	180°
Cylinder Power (IOL Plane)	1.50 D
Cylinder Power (Corneal Plane)	1.03 D
Calculation Details	
Pre-Op Corneal Astigmatism:	1.21 D X 2°
Surgically Induced Astigmatism:	0.25 D X 100°
Crossed-Cylinder Result (corneal plane):	0.97 D X 180°
Anticipated Residual Astigmatism:	0.06 D X 90°

Pre-Op Information

Patient Data	
Flat K	44.24 D
@ Flat Axis	92°
Steep K	45.45 D
@ Steep Axis	2°
IOL Spherical Power (P-IOL)	13.0 D
Surgically Induced Astigmatism (SIA)	0.25 D
Incision Location (IL)	190°

Notes:

8ae69915b9d82bc14d1b3f7659d8361a 4/18/11 23:52:33

V: 3.4.3

New Calculation | Tutorial | Help | Privacy Policy & Legal Terms

Figure 3. *Pearl #2: The use of a toric intraocular lens (IOL) in a patient with pellucid marginal degeneration. Toric IOL calculation was performed using the Alcon online calculator, basing the keratometry axis on the videokeratoscopy (Fig. 2).*

course of the disease, then it is not practical to insert a lens into the eye whose parameters are sure to become inaccurate as the cornea further steepens.

One of the easiest features to screen for is age. If a patient is young, the likelihood of disease progression is usually greater than in someone who was diagnosed 30 years ago. Other factors thought to predict the progression of keratoconus include family history of the disease, recent changes in refraction, eye rubbing, and steep corneal values at baseline.[20] Alfonso et al[19] outlined a set of criteria to assess whether a patient's keratoconus was stable enough to warrant the use of a pIOL: stable keratometry values that are $<$52.5 D, stable refraction for at least 2 years, CDVA of 20/50, and a clear central cornea.

Thus, the pearl here is that in the right situation, both phakic and pseudophakic toric IOLs may be the appropriate choice in a keratoconus or PMD patient with astigmatism. Pending the condition has been stable for several years, both options seem to produce positive refractive results. In the presence of cataract, the pseudophakic IOL is the more prudent choice, but even in cases where no cataract is present, the pseudophakic toric may still be an acceptable choice if the patient is not very young.

■ Pearl #3: The Light Adjustable Lens (LAL) Is an Attractive Option in the Postrefractive Surgery Patient Who Develops Cataracts

Background

Refractive surgeries such as LASIK have forever changed the landscape of cataract surgery. The corneal changes induced by LASIK are well known to limit the accuracy of keratometry measurements used to calculate the correct IOL power.[22,23] As patient expectations continue to grow, so does the need for new methods to achieve more predictable postoperative refractions in the post-LASIK patient.

The current approach to most accurately calculate the proper IOL power to be used in the post-LASIK eye relies on the use of various formulas that attempt to take into account the corneal changes induced by LASIK. Some of these formulas are dependent on obtaining ophthalmic data before the patient's refractive procedures, such as the clinical history method, the Feiz-Mannis method, the Latkany method, the Aramberri double-K method, and the Hamed method.[23] Other formulas that do not require access to prior patient data include the Maloney/Wang method, the Savini method, and the Shammas method.[23] Unfortunately, the refractive predictability achieved by these formulas has been less than ideal, and no 1 method is perfect.

The LAL provides a new solution to the difficult task of achieving increased refractive predictability in post-LASIK patients. The LAL, introduced by Calhoun Vision Inc. (Pasadena, CA), is a new type of lens whose power can be altered postoperatively by the use of ultraviolet

(UV) laser treatments. The lens consists of a UV-absorbing silicone base, with photosensitive silicone monomers dispersed within it.[24] After surgery, the patient is instructed to wear UV-blocking sunglasses at all times. Then, within the first few weeks after the surgery, a series of UVA light (365 nm) treatments are initiated. Such treatments are designed to alter the shape of the lens, as the UV light causes the monomers to polymerize.[25] As the lens changes shape, so does its power, and therefore the patient's refractive outcome. The laser settings are customized for each patient based on their postoperative refraction. If the first laser procedure still leaves room for a better refractive outcome to be achieved, a second laser procedure can be pursued. Once the patient and ophthalmologist are content with the patient's end refraction, 1 to 2 "lock-in" treatments are performed, whereby the laser secures the lens's new shape and position.[25]

Case

A 61-year-old female had undergone successful bilateral LASIK 4 years before her referral to our practice for cataract surgery. Uncorrected visual acuity had declined to 20/400 in the right eye, while maintaining 20/20 in the left eye. Her pupils dilated to >7.2 mm, which is important when considering LAL technology. She had been functioning well with monovision, with a −2.00-D correction in her right eye, the near vision eye. A visually significant cataract was present in the right eye, and surgery was carried out with standard phacoemulsification techniques. IOL power calculation was performed using the Holladay Equivalent K reading display from the Pentacam and the Holladay II formula. Postoperatively, the result was an UDVA of 20/125, refraction of $-4.75 + 1.25 \times 105 = 20/20$, and J1+ at near. After UV-light adjustment, the result was an UDVA of 20/40, refraction of $-2.25 + 0.50 \times 95 = 20/20$, and J1 at near.

Discussion

This case illustrates the effective use of the LAL in a postrefractive patient. As demonstrated, the LAL is an extremely appealing option in patients who have previously undergone LASIK. The LAL allows the focus to shift from rigorous attempts to choose the accurate IOL power preoperatively, to accepting that the chosen IOL power may not be ideal, but at least it can be changed after surgery. Developing new formulas to better calculate keratometry values in these eyes thus becomes less necessary, and the surgeon can instead choose to use the LAL's abilities to alter the IOL power postoperatively.

Although there is not yet any published data regarding the use of LALs in post-LASIK patients, preliminary studies of the LAL have so far shown good efficacy in normal eyes. A study by Salgado et al[26] demonstrated a 6-month mean post "lock-in" spherical equivalent of −0.07 D, reduced from +0.39 postoperatively. In a study by Chayet et al[24], at 9-month postoperatively, 93% of patients had refractions with 0.25 D of the desired outcome. Von Mohrenfels et al[27] reported a mean UDVA of 1.02 in LAL eyes.

The positive results of these early LAL studies are encouraging. The notion of being able to alter the lens power post-IOL implantation is a novel concept in ophthalmology. Perhaps, however, the greatest yield and most dramatic effect of these lenses has yet to be seen – their application in the post-LASIK population.

■ Pearl #4: Toric IOLs Can Be Implanted in the Presence of Loose Zonules, So Long as the Axis Is Maintained and the Capsule Is Supported Appropriately

Weak zonular support can become a challenge for the ophthalmologist during cataract surgery. Several ophthalmic conditions involve zonular weakness, rendering the capsule less stable. Congenital causes of zonular weakness include Marfan syndrome, idiopathic ectopia lentis, and homocystinuria.[28] The more common etiologies of weakened zonules include pseudoexfoliation syndrome, trauma, past ocular surgery, mature cataract, high myopia, and chronic uveitis.[28]

The capsular instability that results from loose zonules makes it difficult for the surgeon to stabilize the bag during phacoemulsification and IOL implantation. Microhooks, such as iris retractors, and capsular tension rings (CTR) are invaluable tools to help augment this stabilization during surgery.[28]

Once the phacoemulsification and IOL implantation have been performed, however, the problem still exists as to how the IOL's position can be maintained within the floppy capsule. There are essentially 2 ways to ensure stable IOL position. The first option is to anchor the IOL in a nonstandard position. Such methods include iris-sutured PCIOLs, transscleral-sutured PCIOLs, flexible open-loop ACIOLs, iris-fixated retropupillary ACIOLs, and iris claw ACIOLs.[29] The second option is to place the IOL in the bag, as in a normal case, but to insert a CTR in order to provide permanent stability to the capsule such that the IOL's position does not shift.

The issue of capsular instability becomes magnified in cases of astigmatism. The success of a toric IOL is reliant on its alignment with the axis of astigmatism.[30] IOL placement is precisely correlated with the markings that the surgeon denotes at the 3 and 9 o'clock positions on the cornea.[30] If the IOL were to shift due to lack of capsular support, then the precision of this technique would be to no avail, and the results would suffer. The following case illustrates an interesting approach to cataract surgery in an astigmatic eye with zonular weakness.

Case

This 51-year-old white male presented to the office on February 8, 2010. He was referred with a history of a detached retina on the right eye in 1996. He had high compound myopic astigmatism, right eye $-10.25+1.25 \times 125$ and left eye $-14.25+3.00 \times 2$. CDVA was 20/100 in the right eye and 20/160 in the left eye. There was evidence of nuclear sclerotic cataract in both eyes and posterior subcapsular cataract in the left eye.

Surgery was discussed for the left eye, and toric IOL was offered. Surgery was carried out on May 6, 2010. During capsulorhexis, it was evident that the zonular apparatus was weak. Four iris hooks were used to support the capsular opening, and phacoemulsification was continued uneventfully. Next the eye was filled with viscoelastic, and scleral tunnels were made superiorly and inferiorly following the Hoffman technique.

In brief, a diamond knife set at 375-μm depth was used to create incisions at the limbus superiorly and inferiorly, and a crescent knife was used to dissect a 3 × 3-mm scleral tunnel posteriorly. Through the centre part of the tunnel a 26-gauge needle was passed through the sulcus so that a double-armed 9-0 prolene suture could be docked sequentially. This allowed for a CTR segment to be placed both inferiorly and superiorly being pulled by the eyelet, using the double-arm sutures. The sutures were then retrieved through the tunnel, the needles cut and the sutures tied within the tunnel. This allowed for excellent support both inferiorly and superiorly. Once the cortical material had been removed with bimanual irrigation/aspiration, a CTR was then placed to further supplement the support. Then, it was possible to inject the IOL implant that was a + 2-D power/+ 3.0 cylindrical correction, model 623T Rayner, based on the preoperative videokeratoscopy (Fig. 4) and results from the toric calculator provided by the website. The lens was aligned at 170 degrees.

Postoperatively, the patient's distance uncorrected vision improved to 20/25 a few days later. Unfortunately, 7 months later the inferior area subluxated where the capsular tension segment (CTS) had been placed. Once again, the lens was repositioned and was sutured to the sclera. This time, once again the Hoffman technique was used; however, an micro vitreoretinal blade was used to create a sclerostomy superiorly so that the lens could be manipulated into proper position. After surgery, once again the vision improved to 20/32 uncorrected.

Discussion

The CTR primarily provides intraoperative support to the capsule during phacoemulsification. Specifically, the CTR is able to spread the tension of the capsule evenly amongst the zonules.[31] Although the CTR

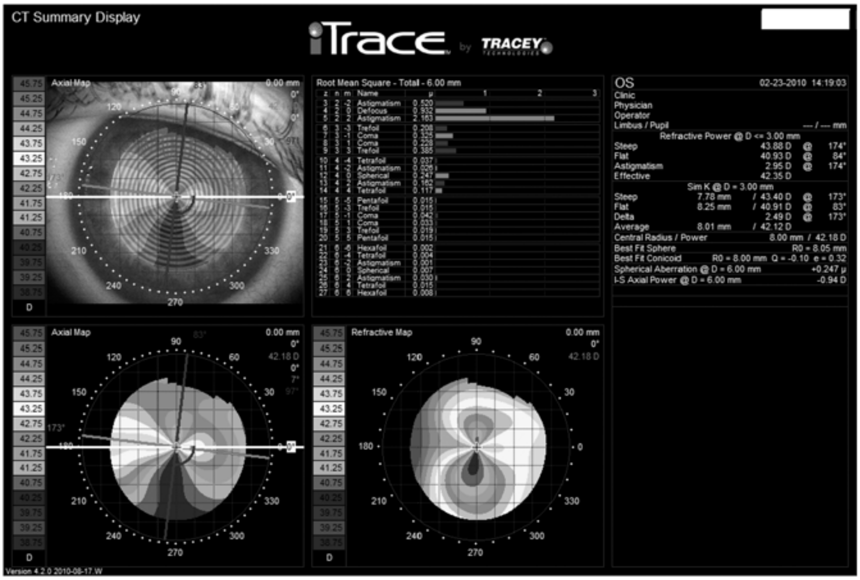


Figure 4. *Pearl #4: Toric intraocular lens (IOLs) can be implanted in the presence of loose zonules, so long as the axis is maintained and the capsule is supported appropriately. iTrace videokeratoscopy displaying regular against-the-rule astigmatism. The marked axis and IOL orientation were maintained throughout the procedure.*

is mainly a means of intraoperative stability, modified CTRs and CTSs can also offer postoperative capsular and IOL support.[32] The CTS and modified CTR are sutured to the sclera, with the effect of greater postoperative IOL stability and decreased decentration. In the case of a toric, such stabilization is of magnified importance in order to maintain IOL position.

Few reports in the literature have focused on the use of toric IOLs in eyes with weak zonular support. Borkenstein et al[33] presented a case of transscleral fixation of a toric IOL (Rayner 570T) in an aphakic eye with postkeratoplasty astigmatism. The case at hand, however, is different, as it illustrates the use of a toric lens that does not need to be sutured within the eye, as long as capsular stability is secured before insertion. Thus, the pearl here is that in select cases of weakened zonular support, a toric IOL may be inserted into the bag in a standard manner, as long as measures are taken to ensure maximal capsular support.

■ Pearl #5: Managing Patient Goals in the New Age of Cataract Surgery

There is little doubt that as cataract surgery has progressed over the last several decades, the amount of options that ophthalmologists now have in their surgical armoires has vastly expanded. As the above cases have illustrated, most ophthalmology problems can now be treated by various surgical methods. There is no 1 right approach to any surgical presentation, as different surgical techniques can lead to the same outcomes.

As the options continue to increase in the coming years, it is important for ophthalmologists to ensure effective communication with their patients. In the face of so many choices, it is the physician's role to understand the patients' goals in undergoing surgery and then point them in the direction of the procedure that is most in line with what they would like to have accomplished. Although it is obvious that certain conditions will most benefit from a specific surgical plan that the ophthalmologist deems most appropriate, a dialogue with the patient may help shed light on the most suitable surgical option in cases where there is no clear benefit to one procedure over another.

The authors declare that they have no conflicts of interest to disclose.

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