Corneal Refractive Tools for the Cataract Surgeon

Surgeons discuss how to use cutting and fine-tuning to improve cataract sugery outcomes.

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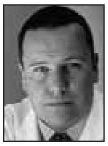
Introduction

BY ERIK L. MERTENS, MD, FEBOPHTH



I joined *Cataract and Refractive Surgery Today Europe*'s Editorial Board in June 2003 and now have the opportunity and privilege to become more involved in this exciting publication.

I would like to introduce myself as the new Associate Chief Medical Editor of *CRST Europe*. As the Medical Director of Eye Center Medipolis, Antwerp, Belgium, it is a very exciting time at my center. After we opened a new clinic in January, our government decided to reimburse eye surgery outside of the hospital. This will result in many changes in the Belgian Ophthalmological Society and will alter the landscape of ophthalmology in my country permanently.

This issue features the cover focus *Transforming Your Cataract Outcomes to the Next Level*, a topic of interest to us all. Patients have much higher demands than in the past, and they are in general younger and more active and want to know before surgery what to expect of their postoperative vision. Therefore, preoperative examinations must be carried out thoroughly, and instruments must be correctly calibrated. A comparison of bilateral measurements provides valuable information concerning reliability and possible postoperative outcomes. Surgeons should calculate IOL power with modern formulas and must customize their A-constants to achieve good results. Looking at corneal topography, an ultrasound biomicroscopic scan of the anterior segment, and measurement of the axial length will assist in producing happy patients.

During surgery, more colleagues are taking astigmatism into account and attempting to correct it as much as possible. For this purpose, toric and multifocal toric IOLs are at our disposal. Other surgeons prefer to correct astigmatism with limbal relaxing incisions, by placing the incision on the steepest axis, or by creating a counterincision to deal with higher amounts of cylinder.

Unfortunately, however, postoperative refractive surprises can occur. How do we deal with this? Refractive surgery can help us to adjust the outcomes after cataract surgery. Depending on the tools available and on the skills of the surgeon, an IOL exchange can be carried out, or an extra IOL can be implanted into the sulcus. If this is not feasible, the cornea can be altered using an armamentarium of different techniques. These include conductive keratoplasty, LASIK, epi-LASIK, and limbal relaxing incisions. In the future, femtosecond laser intrastromal ablations will be used to create multifocal corneas or to correct small amounts of refractive error.

Also, new corneal implants, such as the AcuFocus Corneal Inlay ACI 7000 (AcuFocus, Inc., Irvine, California), are promising. A small pocket is created with the femtosecond laser before the implant is introduced into the cornea. Centration of corneal implants, however, is crucial and not always easy to achieve.

All of these developments pose a continuous challenge to surgeons to keep up to date and become familiar with new techniques. I am sure this issue of *CRST Europe* will help guide you in making the right decisions. In this article, several surgeons provide pointers for developing your corneal refractive skills for use during cataract surgery to achieve the best possible outcome for your patients.

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Fine-Tuning Tools to Improve Outcomes

BY A. JOHN KALENNOPOULOS, MD

It is common knowledge that cataract surgery is now considered a highly refined refractive procedure. For a refractive surgeon who shares a similar practice distribution to mine—approximately 60% laser refractive surgery and 40% cataract surgery—it is an automatic transition whenever evaluating, executing preoperative measurements, performing surgery, and following the patient postoperatively, to focus on the main goal of achieving a successful and safe cataract procedure. Part of this process is a thorough evaluation of the multiple eye functions and measurements.

The refractive aspect of cataract surgery has become a crucial point and, inevitably, a means by which the patient judges the clinical outcome. It plays a major role in the patient's overall satisfaction. We have routinely employed several tools to optimize refractive outcomes in cataract surgery over the past 10 years, which I think have become a great advantage, not only for patients to realize the formality with which we approach the issue of refractive correction, but as something that is reinforced by our excellent results. In our preoperative evaluation, one important measurement is to understand how the patient is functioning—whether it be with glasses, contact lenses, or no correction at all. It is also important to know whether the patient is a driver and if they will drive at night.

An important element in the outcome of the patient's functional future refractive error is the choice of IOL.

PREOPERATIVE ASSESSMENT

Our preoperative cataract surgery evaluation is similar to our evaluation of refractive surgery patients. It includes a dry refraction, after one drop of Mydriacyl (Alcon Laboratories, Inc., Fort Worth, Texas); autorefraction with the Speedy-K (Right Medical, Virginia Beach, Virginia); a Pentacam (Oculus Optgeräte GmbH, Wetzlar, Germany) map, showing the anterior and posterior corneal curvatures and cataract density; and, importantly, a reminder of the angle depths just in case this was missed during the clinician's exam. We perform epithelial cell counts on all patients as a screening tool before the procedure. Additionally, we perform IOLMaster (Carl Zeiss Meditec, Jena, Germany) measurements and a Biograph, which is the inferometry measurement by WaveLight AG (Erlangen, Germany).

In cases in which retinal pathology is also present, we perform ocular coherence tomography (OCT) and a potential acuity measurement (PAM) that will indirectly suggest whether cataract extraction will benefit the patient. Then the patient is evaluated for how well the pupil dilates with 0.1% Mydriacyl. Minor surgical irregularity issues are common in our patient population in Athens. Pseudoexfoliation is encountered in approximately 25% of cases, and issues with pupil dilation are common in this condition. We evaluate patients carefully for the use of medications, especially men for prostate medications, which, as we know, may create floppy iris syndrome.

Examination of the cornea, anterior segment, lens, and zonular stability (by tapping gently on the temporal bone) are also performed. A thorough fundus evaluation with a 78° lens or occasionally a three-mirror lens is used to evaluate the peripheral retina.

Preoperative evaluation of retinal pathologies is necessary because poor visual results postoperatively may be caused not by the surgery but by preexisting retinal pathology. When this is the case, patients tend to express strong disappointment; they would much rather have had this information beforehand. We find it crucial to perform retinal evaluations preoperatively and inform the patient accordingly whether there is an epiretinal membrane, macular degeneration, or signs of diabetic retinopathy—the almost-routine use of OCT in all preop cataract cases has been very enlightening. It is also important to inform the patient if there is any suspicion of the presence of glaucoma.

EXPLAIN THE REFRACTIVE CORRECTION

As far as the refractive side of cataract surgery, we discuss several options with the patient. We offer a standard option, which for us is the aspheric AcrySof IQ IOL (Alcon Laboratories, Inc.). In general, we aim for ametropia and potentially 0.50 D of myopia in the nondominant eye. In hyperopic patients, we tend to aim mainly toward ametropia; in myopic patients, we shy away from ametropia and lean toward 0.50 D of myopia. My clinical experience indicates that hyperopes never like to be myopic and myopes never like to be hyperopic postoperatively. To avoid such refractive surprises, we treat the two groups as different patient populations.

We also offer multifocal IOLs, our top choice being the aspheric AcrySof IQ Restor IOL +3.0 D, and accommodating IOLs, with our top choice being the Crystalens (Bausch & Lomb, Rochester, New York). We discuss the potential advantages and disadvantages of each IOL thoroughly with patients. As a rule, if the patient has significant astigmatism (ie, more than 0.75 D), we use toric IOLs, our top choice being the AcrySof Toric. This IOL has revolutionized our practice over the past couple of years because it accounts for approximately 50% of the IOLs we use after cataract surgery. With an almost predictable cylinder change with our

2-mm incision, it has been rewarding in eliminating postop cylinder and has proven to be a valuable tool toward achieving emmetropia, and of course, greater patient satisfaction.

After we discuss all the options, if the patient has high astigmatism (ie, more than 1.00 D), we compare keratometry measurements among the autorefractor, IOLMaster, Biograph, and Pentacam. We again lean toward using a toric IOL. If the patient does not have significant keratometric astigmatism and does not desire a specialty multifocal accommodating IOL, we go with a monofocal option, targeting ametropia in the dominant eye and approximately 0.50 D of myopia in the nondominant eye to aid with animated vision. If the patient desires correction of distance and intermediate and some near vision, we proceed with informed consent for both the Crystalens and the Restor. A majority of patients lean toward the Crystalens once the issue of night driving is discussed. They do not want to sacrifice quality of nighttime vision for better near vision.

INTRAOPERATIVE TIPS

During the procedure, I always take special care identifying the steepest axis of the eye. Even if the patient does not have significant keratometric astigmatism, I always like to enter with my 2.75-mm incision on the steep axis if it is between 80º and 180º (I am right-handed). If the axis of astigmatism is more than 180º or between 0º and 80º, it is difficult for me to accommodate rotation on the eye to perform such an incision. In these cases, I defer to my favorite technique, which is performing an incision at the 10-o'clock position, at approximately 130º. I then correct the astigmatism with a toric IOL. Incision placement is crucial, and it must be a limbal, clear corneal incision. For a with-the-rule incision, I expect approximately 0.50 D recession in astigmatism from my incision. If the incision is against the rule, meaning between 160º and 180º, there is usually no astigmatic change if the incision is far from the center of the cornea in the long radius.

If we are going to implant a toric lens, it is crucial to mark the horizontal meridians on the eye preoperatively with the patient standing up. We use a standard marker; once the patient is prepped for surgery, we identify the steep axis and always try to match it with the toric IOL implantation.

Handling patients' astigmatism in clear corneal cataract surgery is now an everyday refractive procedure, with reproducible results in our clinical practice. On very rare occasions patients become outliers as far as their astigmatic response to cataract surgery. Thorough evaluation of the pre- and postoperative topographies and refractive results of cataract surgery will make one attuned to the possibility that very simple steps during the cataract procedure can enhance the refractive results, which sometimes become the only aspect by which the patient will be satisfied. Many times, patients do not realize that most procedures focus on the removal of a difficult lens or stabilizing zonules with, for example, capsular tension rings. The patient achieves a plano refraction a few months later—and we all realize how effective this major effort has been in accomplishing this goal.

Every cataract surgeon today, according to their means and equipment evaluation, can play a significant role in treating cataract procedures as refractive procedures. The tools that I mentioned in this article can greatly enhance the visual performance of these patients postoperatively, which is the greatest practice enhancer that I have encountered to date.

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Intraoperative Correction of Astigmatism

BY JOSÉ F. ALFONSO, MD, PHD; LUIS FERNÁNDEZ-VEGA, MD; AND BEGOÑA BAAMONDE, MD

Current cataract surgery procedures are focused not only on restoring visual acuity but also providing the best visual quality for our patients. Incisions placed on the steep corneal meridian, symmetrically opposed, are designed to flatten the steep meridian. A single clear corneal incision (CCI) will have a local flattening effect on the cornea depending on its location, width, and structure.[1-6] Paired opposite CCIs have been found predictable and effective in providing an enhanced effect over a single CCI for correcting preexisting corneal astigmatism in cataract surgery.[7] Surgeons should consider opposite CCIs, taking into account the degree of astigmatism to be treated; possible long-term mechanical instability; and variability of postoperative outcomes that are subject to a high number of variables, such as age, magnitude, depth, and length of the incisions.

Considering these factors, surgeons have tried to measure

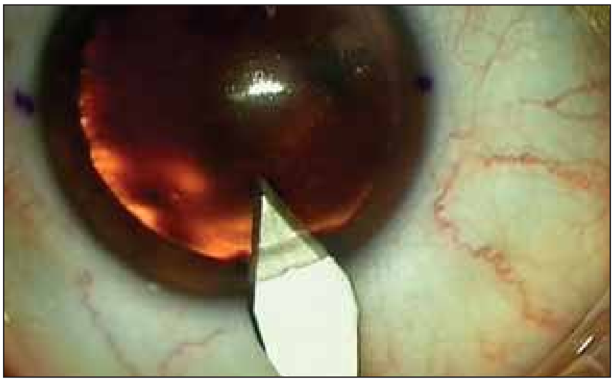

Figure 1. A 3.2-mm clear corneal incision.

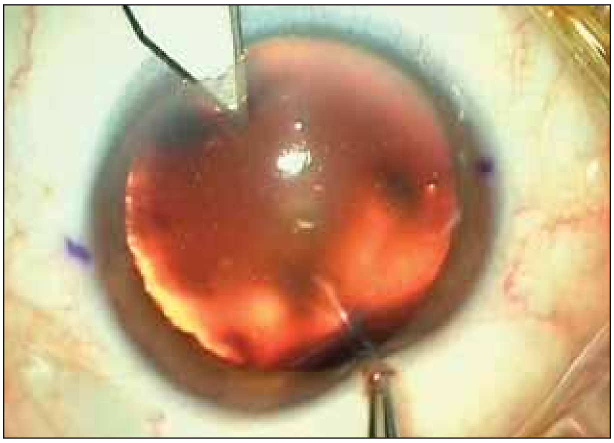

Figure 2. Opposite clear corneal incisions.

and correct astigmatism preoperatively using different techniques taking into account for keratometry or topography.[8] Here we discuss our experience using a single CCI and opposite CCIs for correcting astigmatism in cataract surgery or refractive lens exchange (RLE).

METHOD

We prospectively analyzed 145 eyes of 78 patients who underwent RLE with the Acri.Tec diffractive multifocal IOL (Carl Zeiss Meditec, Jena Germany). Included were 66 women and 12 men patients with an average age of 53 ±8.5 years (range, 45–75). Exclusion criteria included a history of glaucoma or retinal detachment, corneal disease, previous corneal or intraocular surgery, abnormal iris, pupil deformation, macular degeneration or retinopathy, neuroophthalmic diseases, and a history of ocular inflammation.

We used the Infiniti Vision System (Alcon Laboratories, Inc., Fort Worth, Texas), topical anesthesia, and a CCI of 3.2 mm. All procedures were performed by an experienced surgeon (JFA). In the case of opposite CCIs, the second one was not performed intraoperatively. Phacoemulsification was followed by irrigation and aspiration of the cortex and IOL implantation into the capsular bag. There were no complications in any case.

A step-by-step explanation of the technique is as follows: (1) Identify the horizontal meridian preoperatively using a slit lamp; (2) locate the steep meridian intraoperatively; (3) make a 3.2-mm CCI (Figure 1); (4) introduce viscoelastic; (5) make opposite CCIs if programmed (Figure 2); and (6) phacoemulsify and implant the IOL.

The eyes were divided in three groups: group 1 received a temporal CCI; group 2 received steep-meridian CCIs; and group 3 received steep-meridian opposite CCIs with an optical zone of 10 mm. In the first group, we included eyes with astigmatism less than or equal to 0.50 D, in the second group eyes with between 0.75 and 2.00 D, and in the third group eyes with astigmatism between 1.50 and 4.00 D. Astigmatism was evaluated at 6 months postsurgery with Javal keratometry. Target-induced astigmatism, surgically induced astigmatism, and coupling were evaluated using the Alpins method.[9-11]

RESULTS

Mean preoperative astigmatism was 1.21 ±0.88 D (range, 0.00–4.00 D). After surgery, mean astigmatism was 0.76 ±0.59 D (range, 0.00–3.00 D). Preoperatively, 83 eyes (57.25%) had astigmatism of less than or equal to 1.00 D and 62 eyes had greater than 1.00 D. Postoperatively, 124 eyes (85.52%) had change in astigmatism of 1.00 D or less. Table 1 shows the astigmatism after surgery for the three groups.

Eyes with a temporal CCI had an increase in astigmatism of 0.16 ±0.34 D. In eyes with steep CCI, astigmatism decreased 0.46 ±0.36 D, and in eyes with opposite CCIs astigmatism decreased 1.00 ±0.48 D. The difference was sta-

TABLE 1. POSTOPERATIVE ASTIGMATISM FOR THREE GROUPS

	Higher than preoperative	Equal to preoperative	Lower than preoperative
Group 1*	46.67%	35.55%	17.78%
Group 2	4.00%	10.00%	86.00%
Group 3	4.00%	0.00%	96.00%
TOTAL	17.24%	14.48%	68.27%

**Includes patients with spherical error only.*

TABLE 2. COUPLING EFFECT			
Group	Whole sample	With-the-rule astigmatism	Against-the-rule astigmatism
1	-0.04 ±0.36	-0.03 ±0.38	-0.08 ±0.20
2	-0.26 ±0.47	-0.26 ±0.43	-0.28 ±0.64
3	-0.68 ±0.47	-0.66 ±0.40	-0.75 ±0.74

tistically significant among the three groups (P<.05). When we compared the results for target-induced astigmatism and surgically induced astigmatism among the groups and for the entire patient group evaluated, we found that there was a correlation between the parameters despite the difficulty of achieving corrections greater than 2.00 D.

Data for coupling appear in Table 2. Large values were found for group 3 in relation to those found for groups 2 and 1; however, no statistically significant differences were observed.

DISCUSSION

Astigmatism can be eliminated with a variety of surgical techniques, including selective positioning of the phacoemulsification incision, corneal or limbal relaxing incisions, and excimer laser keratectomy. All these methods have some limitations depending upon the degree of astigmatism to be treated. Long-term mechanical instability and postoperative outcomes are subject to a high number of variables, including age, magnitude, incision number, depth, and length. Toric IOLs are also a good alternative for this condition.

In a recent report, surgeons sought to perform phacoemulsification using a CCI in the steep meridian if preoperative astigmatism was significant. In this case, the effect obtained depends on the size and location of the incision.[12,13] In previous research, the use of 3.2-mm incisions resulted in a change of approximately 0.50 D[14] and a 4-mm incision had a result of 1.00 to 1.50 D.[15,16] Our results were similar (approximately 0.50 D) to those of Ben Simon.[14]

It has been previously reported that a superior location induces more effect than nasal and temporal incisions. In the case of opposite CCIs, the literature shows changes from 0.50 to 2.06 D. Tadros et al[17] reported a mean reduction of 0.50 D and surgically induced astigmatism of 1.57 D using 3.5-mm incisions. Lever and Dahan[18] found a reduction of 2.06 D with the same incision size. Differences in outcomes may be attributable to the amount of preoperative astigmatism (Tadros 1.48 D, Lever and Dahan 2.81 D).[17,18] Recently, Ben Simon[14] described a mean reduction of 1.30 D with a surgically induced astigmatism of 1.80 D using opposite CCIs of 3.2 mm. Qammar and Mullaney[20] found similar results (topographical astigmatism correction of 1.23 D) using the same incision size. Although Tadros[17] and Lever and Dahan[18] did not find significant changes in the spherical equivalent, Ben Simon[14] reported significant changes using both CCI and opposite CCIs. In our study, when we analyzed the coupling effect, we did not find significant changes; however, we observed more effect with opposite CCIs than a single CCI.

We found that correcting astigmatism preoperatively using a corneal incision has several advantages: It is a simple procedure, it is not necessary to use specialized instruments, it is stable,[21] the optical properties of the cornea are maintained, and it is possible to perform secondary procedures following this surgery. Possible disadvantages include the surgeon's position during the procedure, and in the case of more invasive opposite CCIs, the increased risk of endophthalmitis.[23,24]

In conclusion, we consider this a safe, effective, and stable procedure for preoperative astigmatism correction. Surgeons should keep in mind that different incision sizes, location, corneal thickness,[25] and optical zones may affect the expected outcomes, and the current nomogram should be appropriately modified.

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Incision Size, Shape Can Improve Phaco Outcomes

BY ROBERT KAUFER, MD

There are currently three available phacoemulsification modalities: coaxial (incision size greater than 2.6 mm); microcoaxial (incision size between 2.2 and 2.4 mm); and microincision cataract surgery (MICS; incision size smaller than 2 mm). I have found that both wound size and shape play a role in surgical outcomes.

First, a clear corneal 2.2-mm incision is superior to both larger and smaller incisions. A 2.2-mm incision is less likely than larger incisions to induce astigmatism, leak or be unstable postoperatively, or to result in endophthalmitis. Additionally, 2.2-mm incisions are superior to smaller wounds because the surgeon's ability to move the instruments is not hindered by the small incision size.

Square or nearly square clear corneal incisions have been found to be optimal, with no hypotony or wound leakage. For these reasons, I routinely perform phaco through a 2.2-mm square incision created with Intrepid ClearCut incisional instruments (Alcon Laboratories, Inc.).

INCISION SIZE

Smaller incisions have certain benefits, such as less induced astigmatism. Additionally, they are better at self-sealing than larger incisions, which can reduce the risk of wound leakage and endophthalmitis. However, if incisions are too small, the surgeon's ability to manipulate instruments is hindered. The smallest incisions (1.1–1.2 mm) require the use of unsleeved instruments, which increases the risk of mechanical or thermal injury to the wound.

A recent study by Masket et al[26] compared 2.2-mm incision microcoaxial phacoemulsification to traditional 3-mm coaxial phacoemulsification with regard to surgically induced astigmatism after temporally oriented clear corneal incision cataract surgery.

This prospective, randomized study included 22 patients who underwent bilateral clear corneal cataract surgery. One eye underwent 2.2-mm incision microcoaxial phacoemulsification with IOL implantation, and the fellow eye underwent traditional 3-mm incision coaxial phacoemulsification with IOL implantation. In the eyes that underwent microcoaxial phacoemulsification, a 200-µm groove was made at the temporal limbus of the clear cornea before the 2.2-mm incisions were made with a diamond keratome. In the eyes that underwent coaxial phacoemulsification, a metal keratome was used to create a 3-mm incision without a precut groove. A handheld Retinomax K-plus 2 Autorefractor (Nikon, Tokyo) was used to measure keratometric astigmatism both preoperatively and at 6 weeks after surgery.

The 2.2-mm incision generated statistically significantly less surgically induced astigmatism compared with the 3-mm incision. The mean change in the magnitude of keratometric astigmatism was 0.10 ±0.08 D in the eyes that received 2.2-mm microcoaxial incisions and 0.32 ±0.20 D in the eyes that received 3-mm incisions. Vector analysis showed the mean magnitude of surgically induced astigmatism was 0.35 ±0.21 D in the eyes with 2.2-mm incisions and 0.67 ±0.48 D in the eyes with 3-mm incisions.

Additionally, 2.2-mm microcoaxial incisions have been shown to be less likely to leak.[27] In 2005, Masket and colleagues reported the results of a study in 15 human cadaver eyes. These eyes were divided into three groups: five eyes had a 2.8-mm coaxial incision; five had a 2.2-mm microcoaxial incision; and five had a 1.2-mm bimanual microincision.

All eyes underwent phaco with longitudinal ultrasound and standard settings. One of the five eyes that received a coaxial incision and all five of the eyes that received bimanual microincisions had spontaneous wound leakage, while none of the eyes that received microcoaxial incisions experienced wound leakage.

INCISION SHAPE

In addition to wound size, wound shape has also been found to affect outcomes. Clear corneal incisions that are square or nearly square in surface architecture have been found to be stable postoperatively, with no hypotony or wound leakage.[28] Investigators conducted a retrospective chart review of 60 patients who had clear corneal cataract extraction between January and September 2006. Of these 60 patients, 50 had a square 2.2-mm incision, and 10 had a nearly square 3-mm incision. The physical stability of the incisions was evaluated by intraoperative confirmation of incisional sealing and intraocular pressure (IOP) measurements during the early postoperative period.

The mean postoperative IOP was 19.2 ±4.9 mm Hg (range, 11–35 mm Hg) in the eyes with 2.2-mm square incisions and 16.6 ±5.2 mm Hg (range, 10–25 mm Hg) in the eyes with 3-mm nearly square incisions. None of the patients in either group demonstrated any evidence of hypotony or wound leakage.

Because square incisions have been found to be optimal, my instruments of choice are the Intrepid ClearCut incisional instruments. With these knives, the blade geometry is designed to produce square incisions and improved wound architecture. They also have sharpness with feel, which allows excellent tracking, and they were designed for both near clear or clear corneal incisions.

First, I make a perpendicular groove at the limbus of approximately 250 µm. Then I proceed through the stroma up to a mark on the blade. I then point inward into the anterior chamber. I make a 2.2-mm nasal incision in the left eye and a 2.2-mm temporal incision in the right. Then I create the paracentesis with the stab knife.

In conclusion, to ensure an optimal outcome, I recommend a 2.2-mm square incision. Optimal microcoaxial phaco is more than just a small incision, however. It is dependent on an integrated system that includes incision instruments, microcoaxial tips and sleeves, fluidics, cartridge/injector delivery system, and IOL material suitable for a wide range of powers. ■

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