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PERSPECTIVES IN REFRACTION

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Avoiding Refractive Problems in Cataract Surgery

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Abstract. A good visual result after cataract surgery and intraocular lens implantation depends on preoperative determination of an "ideal" postoperative refraction. This will depend on the refractive error in the other eye and whether the cataract is monocular or binocular. Methods are outlined for calculating the postoperative refraction and refracting the pseudophakic patient after surgery. (**Surv Ophthalmol 32:**357–360, 1988)

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As cataracts advance, vision eventually decreases, and optical and pharmacological therapies no longer bring about acceptable acuity. At that point, surgical intervention is reasonable, and nowadays, that is likely to mean an extracapsular cataract extraction coupled with insertion of a posterior chamber intraocular lens (IOL).

Preoperative Evaluation

Before you and your patient embark on a surgical adventure, it is prudent to assure yourselves that the visual loss is indeed due to the cataract and not to some other deficit, such as macular degeneration. Several available instruments can help differentiate between cataractous and noncataractous causes of decreased vision: the Potential Acuity Meter™, the Super Pinhole™, the laser interferometer, and the Blue Field Entoptic Scope™.

When the cataract is dense, these tools are less important, since removal of the cataract will almost always solve the problems. There will usually be at least some visual improvement, and simultaneously, you will be able to directly examine the retina for diagnosis and therapy. But when the cataract is only moderate, particularly when it is the nuclear sclerotic type, it is not always easy to determine preoperatively how much of the reduced vision is actually being caused by the lens opacity. Here, the information provided by the aforementioned instruments is useful indeed, and supplements what you can learn with your retinoscope, direct ophthalmoscope, and slit-lamp. While the latter are certainly helpful for studying the cataracts, they do not permit a quantitative assessment of macular function, and such an assessment is important to help you better predict the visual outcome of surgery and provide a more realistic expectation for your patient.

The Ideal Postoperative Refractive Error

Modern surgical techniques now permit you to tailor-make the refractive result. Improved ultrasonography, keratometry, and intraocular lens power calculation formulas allow you to achieve a refraction postoperatively that is within about one diopter of the desired end-point 70% of the time.[1] So, once you have decided that cataract surgery and lens implantation are warranted, you will need to select an appropriate postoperative refractive target. How one chooses the "ideal" postoperative refraction for a specific patient is based on the refractive error of the other eye and its visual status, and whether the cataract is monocular or binocular.

MONOCULAR CATARACT

A cataract that is monocular is usually a result of trauma, although age-related (senile) cataracts can be so asymmetric that you will not be contemplating surgery on the second eye any time soon. Anyway, with a monocular cataract, since the vision in the unoperated eye is good, we suggest the following guide: Try to achieve a final postoperative refraction that is no more than three diopters (D) different in power in the vertical meridian from that in the unoperated eye (even though that sometimes means you will be aiming to produce a significant postoperative ametropia in the operated eye).

The main reason for avoiding more than a three-diopter difference in the vertical meridian is because of the differential vertical prism induced by spectacles during up- and down-gaze. The vertical anisometropia fosters intermittent vertical diplopia — in down-gaze (e.g., when reading or eating) and in up-gaze e.g., when viewing overhead traffic lights or in movie theatres with an elevated screen). Spectacle-induced horizontal prism disparities rarely cause problems, because patients normally have large horizontal vergence amplitudes that they can use to help compensate. Not so with vertical amplitudes, which are much smaller.

Of course, the prism problems in down-gaze can be reduced by prescribing slab-off or asymmetrical bifocals, but the best solution is to avoid the problem altogether by properly selecting the postoperative refractive target. The three-diopter difference was arrived at empirically, by extensive clinical experience, but we suggest you aim for even less, because there is a ± 1 tolerance in the intraocular lens power calculations. So, try to achieve only a 2 D difference; that is, two diopters closer to emmetropia than the error in the vertical meridian of the unoperated eye.

If the preoperative astigmatism in the eye to be operated is less than one diopter (and it usually is), you can substitute the spherical equivalent error for the error in the vertical meridian; otherwise, you will have to use the latter.

A less important consideration when choosing the postoperative target is the preoperative aniseikonia (image size disparity). When the retinal image size is different in the two eyes, especially horizontally, problems can occur with depth perception and spatial distortion. A typical complaint is, "Doctor, I see everything clearly, but these glasses are just not right . . . everything looks weird."

To reduce aniseikonic problems, you can modify spectacle lens base curves, thicknesses, and vertex distances.[2] Although most patients will eventually adapt to the aniseikonia caused by moderate anisometropia, you should still try to have less than a three-diopter difference in the lens powers to keep postoperative aniseikonia from being clinically intrusive. Interestingly, aniseikonia can occur with less than a three-diopter refractive difference, when axial length discrepancies exist between the two eyes. Following a retinal detachment repair, for example, an encircling element can cause a significant axial lengthening (and myopia) of the operated eye. If that eye subequently develops a monocular cataract that needs removal, you should *not* attempt to keep that eye myopic by inserting an overpowered intraocular lens. Instead, you should try to match the refractive error present in the nonoperated eye. While this might produce some retinal image magnification (created by the increased axial length) and aniseikonia, it is more important to reduce the spectacle's vertical power difference between the two eyes to less than three diopters. Equal retinal image sizes are fine, but of little consolation to the patient who also has diplopia, which is always intolerable — aniseikonia is less so, since its related symptoms rarely last more than a few weeks anyway. Again, concentrate on assuring that postoperatively the eyes will have less than three diopters difference in the vertical meridian.

Following is an example that should help clarify some of the considerations.

Manifest Refraction (Preoperative)

OD	−9.00 +2.00 × 180	20/100
OS	−6.00 +3.00 × 180	20/20

Keratometry

OD	43.00 @ 90 / 45.00 @ 180	OS	43.00 @ 90 / 46.00 @ 180

The patient, a 40-year-old man, had blunt trauma to his right eye four years ago. A subsequent nuclear cataract developed gradually, along with a progressive increase in his myopia. Since the left eye had no refractive change during the four years, we felt that the cataract in his right eye (OD) was indeed monocular.

This man was unhappy with his poor acuity OD, and since he wanted to experience the blessings of binocularity again, we agreed to remove the cataract. Our objective was to select a postoperative refraction for the right eye that would restore binocular vision without inducing visual symptoms.

The preoperative spectacle power in the left eye (OS) in the vertical meridian is −3.00 D. (The cylinder axis at 180° means the +3.00 D of astigmatic power acts in the vertical meridian. That +3.00 D added to the −6.00 D of sphere totals the −3.00 D indicated.) We want the postoperative spectacle OD to be 2 D nearer emmetropia in the vertical meridian than the −3 D now present in the vertical meridian OS. (That is, we want to end up with a −1 D refractive correction vertically.) Since we know from the preoperative keratometry that the corneal astigmatism OD is 2 D and we do not plan to change the corneal shape by the cataract surgery, we should still have 2 D of corneal astigmatism OD (axis 180) postoperatively. To attain a −1 D correction in the vertical meridian OD, we will try to obtain a postoperative refraction of −3.00 +2.00 × 180.

For most IOL power calculation programs, one uses the spherical equivalent of the target refraction as part of the input data. In this example, then, the spherical equivalent of the postoperative target refractive error is −2D. (This is one of the values that is used to determine the IOL power.)

In this case, as stated, we wanted to keep the postoperative corneal powers OD the same as those existing preoperatively. But if you want to alter the corneal power permanently — to eliminate the against-the-rule astigmatism present in the example above — to determine the postoperative target refractive error, you should use the *predicted* postoperative K-readings (and astigmatism) and not the preoperative measurements. For example, in this patient, you might try to reduce the astigmatism by suturing the wound tightly at 12 o'clock (the 90° meridian), causing corneal compression and steepening of the vertical meridian to make the cornea more spherical. Since (as we learned empirically) the postoperative corneal powers will usually end up about ⅔ to ¾ of the way between the original meridional keratometry readings (nearer to the steeper one), in this patient the spherical cornea would be approximately 44.50 D, [¾ (45–43) = ¾ (2) = 1.5 D; 1.5 + 43 = 44.5 D]. *This* is the keratometry reading that you should input for calculating the intraocular lens power.

Of course, you can also avoid vertical diplopia by correcting the unoperated, ametropic eye with a contact lens; then, you can aim to make the operated eye emmetropic. This combination is certainly a viable alternative, but it requires that you find out preoperatively whether or not your patient will be a good contact lens candidate. If he cannot tolerate a contact lens on the eye that will *not* be operated on, you must know that first, while you can still change your planned refractive target for the operated eye.

BINOCULAR CATARACTS

When a patient has binocular cataracts (or, a monocular cataract with the noncataractous eye somewhere near emmetropia), the optical considerations are very much simpler: Set your postoperative target between plano and −1 D. There are several reasons for choosing this range. IOL power calculations are not exact, the tolerance being about ±1 D, so aiming for mild myopia reduces the risk of inadvertent postoperative hyperopia. Moreover, achieving 1 D of myopia assures that the uncorrected patient will be able to see well at some useful distance (here, in the intermediate zone), and will also be able to see fairly well at near and at distance, too.

It is important that prior to surgery you have a thorough discussion with the patient as to his visual needs and wishes. Many elderly have no need nor desire to drive; many don't even watch television. Some spend a great deal of time reading or doing near-work, and would be elated to wind up 2 to 2.50 D myopic so they can perform many near tasks without spectacles. If they have been myopic for most of their lives, most would be quite happy to remain so; others really do want a change. Still others do want to drive or spend a great deal of time watching television or going to the movies. Even if they have been emmetropic most of their lives, a mild postoperative myopia of, say, 0.25 D, would leave them delighted. Anyway, preoperative explanation of the surgical predictability (or lack of it) of the final refractive error will help avoid the dissatisfaction that is bound to occur if the result does not turn out to be what was desired.

The adjustment period (time between surgery on the first eye and the second eye) may present a real problem, especially when cataracts are bilateral and the preoperative refractive error is significant. For example, a patient has 20/100 cataracts in both eyes and wears +5.00 D OU spectacles. You decide to operate on the first eye and aim for emmetropia. In the postoperative adjustment period, she will obviously find that the vision in the operated eye will be poor when wearing her old prescription. (And with either those old glasses, or with no glasses at all, she would have a full 5 D of anisometropia.) Thus, we advise giving this patient an early temporary prescription: Plano in the operated eye and +3.00 D (or less) in the unoperated eye to avoid the diplopia that would occur when more than a three-diopter difference exists between spectacle lenses.

We cannot emphasize enough how important it is to openly discuss everything, including the adjustment (transition) period. Many second-eye operations have gone to other surgeons simply because someone failed to be sympathetic and explain the optical problems that can occur during the intersurgical waiting period.

Helpful Hints in Refracting the Pseudophakic Patient

After cataract surgery has been performed and an intraocular lens implanted, it usually takes from four to eight weeks for the new refractive error to stabilize. The exact time depends on many factors, such as size of the incision, the amount and duration of topical steroids, suture material, etc. Nevertheless, six weeks is fairly typical.

Retinoscopy is an excellent way to begin refracting your patient, but postoperative irregular astigmatism, dim reflexes and lack of retinoscopic skill with a pseudophakic eye sometimes make it hard to do a good refraction. Moreover, doing a manifest refraction "from scratch" may be especially difficult in this elderly age group, particularly when there is significant cylinder involved. All this suggests that an objective method — at least for starting the refraction — can help speed things up significantly. If an automated refractor is not available, a simple way of approximating the postoperative refractive error is by combining data: (1) the postoperative keratometric readings and (2) the spherical equivalent target you used before surgery to determine the IOL power.

Example: A patient with postoperative keratometry of 42.00 @ 180 and 44.00 @ 90 was targeted for a spherical equivalent correction of −0.50 D. Since keratometry indicates that the patient now has 2 D of with-the-rule corneal astigmatism, the refractive correction that achieves a −0.50 D spherical equivalent would be −1.50 +2.00 × 90. This is the correction to place in front of the patient's operated eye. Then, refine it with spheres (or better yet, with cross cylinders, if you can). You should find this simple technique surprisingly successful.

Sometimes, the corneal astigmatism measured by keratometry does not equal the astigmatism found at refraction. Usually, this discrepancy is due to the presence of irregular corneal astigmatism induced by the surgery, which makes keratometry measurements from the central cornea unpredictable and inaccurate. Another, less common cause for the disparity is a tilted or decentered IOL. While this can certainly induce astigmatism, the lens tilt has to be really significant for it to do so. (An IOL tilted about the horizontal meridian induces plus cylinder axis 180°. The *correcting* lens, of course, will be a minus cylinder axis 180 (or a plus cylinder axis 90). When a 20 D IOL is tilted 10°, 20°, or 30°, the cylinder power induced will be 0.50 D, 2.00 D, or 5.00 D, respectively. A 10 D IOL generates half these amounts, and a 30 D IOL generates half again more than the 20 D lens). It is apparent, then, that an average IOL has to be tilted more than 10° to be clinically important, and that only occurs rarely.

Another possible cause of disparity between keratometric astigmatism and refractive astigmatism is high ametropia. For example, if the spherical portion of the sphero-cylindrical correction is +10 D, the astigmatism in the spectacle plane will be about ⅔ that at the corneal plane. The reverse is true if the spherical error is −10 D, in which case the keratometrically measured corneal astigmatism is ⅔ of the spectacle astigmatism. Since the use of an IOL hopefully eliminates high ametropia, this particular cause of the disparity is rare in the pseudophake.

Early Opacification of the Posterior Capsule

Mild haze of the posterior capsule can make refraction unpredictable. We have seen patients consume enormous quantities of minus and high cylinder to attain 20/30, only to find that, after capsulotomy, the refractive error reverted to what was expected. Any explanation of why this occurs would be pure conjecture. Perhaps, the high correction somehow enhances image contrast or elongates the letters making them more legible. In any case, we suggest that you avoid handing out any unusual prescription until after the capsulotomy has been done and the refraction repeated.

The Final Postoperative Spectacle Prescription

Once the refraction is stable, give the final prescription. The art of translating the best refraction to the final prescription is no different for the pseudophakic patient than for any other patient. However, the elderly are less able to adapt to oblique cylinders and large astigmatic corrections, so try to minimize these effects.[3] Attend carefully to the optical and refractive considerations of pseudophakes, and you will find that they will be among your most appreciative patients.

References

1. Milder B, Rubin ML: *Fine Art of Prescribing Glasses,* Triad Publishing Co., Gainesville, 1979, pp 186–187
2. *Ibid,* p 83
3. Holladay JT et al: A three-part system for refining intraocular lens power calculations. *J Cataract Refract Surg 13:*17–24, 1988

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