Multifocal Intraocular Lenses and Corneal Refractive Surgery

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Patients that either had refractive laser enhancement or cataract surgery with multifocal intraocular lens implant have high expectations for good vision free of need to use any other visual aid like spectacles or contact lenses.

The eye is actually an optical system of two refractive planes: the cornea and the intraocular lens. These two refractive organs concentrate light rays from infinity to a certain focal point. If we want to change the focal, point we can do it either by changing the corneal refractive power, by changing the lens power, or by changing both. As our aim is to free the patient from the need to use spectacles or contact lenses, it is only reasonable to use all the tools we have – changing the refractive power of the cornea, lens or both.

While discussing multifocal intraocular lens implant and laser refractive surgery, there are two possible clinical conditions – multifocal intraocular lens implant after refractive laser (or radial keratotomy) treatment and refractive laser enhancement after multifocal intraocular lens implant. These two possible conditions raise different issues to be considered as timing of procedures, corneal topography, aberrations, lens power calculations, amount of the needed refractive power change, etc.

7.1 Multifocal Intraocular Lens Implant After Radial Keratotomy or Corneal Excimer Laser Surgery (Lasik in PRK)

Radial keratotomy and refractive laser treatment on the corneal surface have been widely done for the last 3–4 decades. Therefore, it is no surprise that the amount of patients needing cataract surgery after previously having refractive surgery on the cornea is in incline and will continue to rise in the future. There is, however, surprising paucity of the literature on this topic, and the most concern of what was published so far deals mainly what are the proper intraocular lens power calculations. In a study assessing safety, efficacy, and predictability in eyes that had refractive lens exchange with implantation of spherical diffractive intraocular lens after previous hyperopic laser in situ keratomileusis, published in 2009, this procedure was found to be safe, effective, and predictable [1]. A review, published in 2013,

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found that the use of hybrid refractive-diffractive multifocal intraocular lenses in eyes with previous myopic or hyperopic laser in situ keratomileusis can result in good refractive results but a warren of possible refractive surprises that may require further intervention [2].

The main three concerns while planning to implant an intraocular lens after laser in situ keratomileusis or after radial keratotomy are:

- Stability of the corneal refractive power. This is an important limitation for previous radial keratotomy cases and one of the reasons to contraindicate the multifocal IOL in the aging patient. Corneal topography and corneal aberrometry: The corneal topography pattern should be mostly regular. Severe or moderate corneal irregularity as measured by corneal aberrometry is to be considered a contraindication for multifocal IOLs. In general, corneas affected by more of 1 micron of higher corneal aberration (HOA), especially if they are caused by high levels of coma, should not be considered as good candidates for multifocal IOL implantation. A very important consideration in the analysis of the eye with total eye aberrometry is to ascertain if the aberrations origin is the cornea or the lens and accordingly to plan the next stage. Operating and replacing the lens while leaving the corneal aberrations untreated will result in an unsatisfactory visual outcome.
- Lens power calculation. Difficult to perform as its precision is affected by multifactorial clinical and anatomical variables.
- Quality of the retinal image following multifocal IOL implantation. Depends mainly on the anterior corneal surface and, to a lesser extent, on the posterior corneal surface. Corneal aberrometry is, in our opinion, of major help in making the decision. Patients with more than 1 micron of higher-order aberrations are not good candidates for multifocal IOLs.

There is no logic in operating the cataract in an eye with an unstable corneal refractive power. Luckily enough, most patients that need cataract surgery had the corneal refractive treatment long ago and while needing a cataract surgery have a stable cornea and a non-changing corneal refractive power. In the minority of patients that do not show corneal stability, or developed cataract in a short time after the corneal refractive treatment, surgery must be postponed, if possible until the cornea reaches a steady state and a steady refractive power. If such stability is not achieved prior to the cataract surgery, refractive surprise may occur, and the patient might have to have another procedure such as a lens exchange or another refractive laser treatment.

An attention to corneal topography and possible existence of corneal aberration is important in planning cataract extraction and multifocal intraocular lens implant. Not all the corneal topography instruments are able to detect delicate corneal changes and aberrations and one should know the limitations of the current in use machinery. If the corneal surface is not regular and a further laser treatment can repair this irregularity, such a treatment should be considered prior to the cataract operation. If the previous treatment was not properly centered, one should consider performing another corneal laser treatment. If it is possible, the corneal surface should be made as regular and without aberrations as could be since eliminating astigmatism and corneal aberrations is a key to success in multifocal intraocular lens implant. Laser enhancement and afterward recovery and corneal stability are a time-consuming process but inevitable if we want good refractive results and patients' satisfaction.

Calculating the power of the intraocular lens to be implanted, after corneal incisional refractive treatment, is not always accurate and hyperopic shift after cataract surgery might occur. Power of the implanted lens is calculated by formulas that use the A constant of the lens, the axial length of the eye, and the corneal refractive power (K readings). The reasons for the miscalculations lie on the inability of keratometers to measure accurately K readings of the corneal center area (approx. 2 mm diameter) after corneal refractive treatment and on the fact that the outer and inner surfaces of the cornea may

change in an unpredictable way after these treatments. As a role, patients that previously had corneal refractive treatments (laser in situ keratomileusis, photorefractive keratomileusis or radial keratotomy) have to be informed that the intraocular lens power calculations are not always accurate and that a further operation for exchanging the lens may be needed in the future.

There are a few ways to calculate the lens power in these patients, but none of them is 100% accurate. The most accurate way of calculating the lens power is the *clinical history method*. To use this method we have to have the refractive error and the K readings before the refractive treatment and the refractive error after the treatment. In this method, we calculate the change in the spherical equivalent (the data after the corneal refractive treatment have to be that of a stable refractive power, long enough after the treatment, and unaffected by the cataract which might cause a myopic shift) [3].

Example *If the average K reading before the refractive treatment was 44.00 D, and the spherical equivalent was −8.00*

The spherical equivalent before the refractive treatment at the corneal plain was-

$$-8.00 / \left[1.00 - 0.012 \times \left(-8.00\right)\right] = -7.30 \left(\text{vertex distance is} 12 \text{ mm}\right)$$

If the spherical equivalent after the treatment is −1.00, we can calculate the new spherical equivalent at the corneal plain the same way:

$$-1.00 / \left[1.00 - 0.012 \times \left(-1.00\right)\right] = -0.98$$

The change of the refraction at the corneal plain is therefore: −7.30 – (−0.98) = −6.32

Now we can calculate the correct average reading by reducing the change of corneal power from the prior corneal power: 44.0 − 6.32 = 37.68D

If we have only the K reading and the refraction prior to the treatment, we have to assume that after the treatment the refractive error was 0. By using the SRK formula: Lens power = A constant – 2.5Axil length – 0.9 K reading. Assuming that there was no change in the spherical equivalent since the treatment, we can calculate the lens power:

Example *A constant= 118.4, axial length= 25.00 mm, Prior average K reading =44.00 and the refraction was −8.00.*

The new K readings 44.00 − 8.00 = 36.00 and the lens power is:

$$118.4 - \left(2.5 \times 25.00\right) - \left(0.9 \times 36.00\right) = 23.50$$

If we know the refraction before and after the treatment but we do not have any information of the previous K reading, we reduce 20% of the k reading that we measure.

Example *If before treatment the refraction was −8.00 and now it is −1.00, then the change is: −8.00 − (−1.00) = −7.00 20% of that change is −1.40 If the measured K reading is 40.00 we have to reduce 20% which means that the correct corneal power is: 40.00 − 1.40 = 38.60.*

If we know only the refraction before treatment, we can use the Feiz–Mannis method in which we calculate the IOL power using the pretreatment keratometry. This calculation is then increased by the amount of refractive change at the spectacle plain divided by 0.7 [4].

Another calculating method was originally outlined by Holladay. In this technique, a *contact lens* is used in order to measure the accurate corneal power. This method is very accurate but is actually impractical, takes a lot of time, and requires an experienced examiner. Best corrected visual acuity has to be 6/24 or better. At first we measure the existing refraction. Then we put a hard contact lens which its power and base curve are known, and we measure the refraction with the contact lens.

If there is no refractive change the corneal power is similar to the lens power. If there is a myopic shift, the contact lens has more power than the cornea by the amount of the myopic change. If there is a hyperopic shift, the cornea

has more power than the contact lens by the amount of the refractive change.

Another formula considered as accurate in these patients is the Haigis L formula in which the measured corneal radius is "corrected" and the IOL power calculation is accurate. The Haigis L formula is [5]:

$$\text{Corrected radius} = \frac{331.5}{-5.1625\,\text{X measured radius} + 82.2603 - 0.35}$$

For practical use, some of the modern keratometers have a built-in calculating system for patients after refractive treatment, and there are some Internet sites that provide online calculators which are quite accurate. Anyhow, the patient should know that intraocular lens power calculations after refractive treatment may eventually bring an undesired refractive surprise and a lens exchange might be needed.

At present moment, and confirming recent reported evidence, our preferred methods for MfIOL calculation following previous myopic lasik are the "Flat K" method of the Holladay II consultant formula or the ASCRS-min method available at the ASCRS Calculator.

If the three influencing factors, stability of the corneal refractive power, corneal topography, and proper lens power calculation, are considered, the outcome of the cataract surgery with multifocal intraocular lens implant in patients that previously had corneal refractive surgery should be good and no different than those who did not have a previous corneal refractive treatment.

There are various calculators one can use and are available in the internet there you have to put in the K readings of the 2 main axis and the axial length of the eye. As time goes by, more and more patients that had in previous years laser refractive surgeries get older and become "cataract patients" – therefore mastering the kens power calculation becomes a necessity for the modern cataract surgeon. We are lucky to have different instruments that have already a built-in calculating system, and we can approach the Internet for extra help; however, there is no replacement for a human doctor who knows how these calculators work and what are their pitfalls. Whatever your experience is and no matter how confident you are, you should explain and emphasize to the patient that the final outcome may be other than ideal and some of the patients that had laser refractive surgery might need a lens replacement after cataract surgery. Shifts are usually toward hyperopia.

7.2 Laser Refractive Surgery After Multifocal Intraocular Lens Implant

The high rate of success of multifocal intraocular lens implant and satisfied patients rose patients' expectations for good visual acuity in all distance without the need to use spectacles or contact lenses. Though intraocular multifocal lenses design improved, related glare and halos were reduced and surgeons' experience and confidence in these lenses increased, there are some cases in which the final visual outcome is not satisfactory [6, 7]. Out of these patients the vast majority have some residual refractive error – myopic or hyperopic shift or residual astigmatism.

Since our aim is to give the patient a good all distances visual acuity free of the need to use any other correction, we can use laser refractive surgery (or keratotomy) to correct this residual refractive error. Previous studies showed that laser refractive surgery, mainly laser in situ keratomileusis, particularly with femtosecond laser flap creation is a safe and effective treatment in correcting this refractive error [8]. On the other hand, patients' complaints are not necessarily due to refractive errors, and still we must try to understand them; sometimes a slight refractive error may cause a lot of discomfort to the patient. Makhotkina et al. found that the incidence of unsolicited negative dysphotopsia after sequential cataract surgery appears to be a substantial underestimation of complaints identified in active interviewing. Although symptoms are not bothersome in the majority of cases, some patients with undiagnosed severe negative dysphotopsia may benefit from reassurance or secondary treatment [9].

There are some considerations that must be addressed prior to performing a secondary laser in situ keratomileusis treatment in these patients [10]:

- Refractive stability. After cataract surgery a few healing procedures take place as adherence of the intraocular lens to the lens capsule which may take 2 months after operation and corneal changes which may take 6 months. After 6 months dehiscence of the corneal self-sealed incisions is unlikely to occur during the flap creation [11]. Due to these healing processes and the refractive stability it is wise to wait for 6 months after the cataract operation before proceeding with the laser treatment. Waiting, in this case, and restraining from treatment until the time is right is a good thing to do.
- Refractive evaluation. Autorefractometers and wavefront refractive error measurements may be incorrect in these patients. A careful evaluation of the refractive error is obligatory in these patients. Retinoscopic evaluation in addition to autorefractometer measurements is recommended in these patients as well as a manifest refraction conformation just prior to the laser treatment.
- Preoperative exam should include comparison of current findings with the cataract preoperative findings in order to determine if the laser treatment will be beneficial to the patient and if it is safe. Corneal thickness, corneal diseases, pupil problems, intraocular lens position, and clarity of the posterior capsule should be evaluated. If there is any pathological finding, an alternative treatment should be considered. Last but not least a thorough funduscopic examination to detect any retinal problems is important.
- Is the residual refractive error the cause of the unsatisfactory visual outcome or is something else the cause for it? There is no use in laser treatment if other things like lens position and aberrations, posterior capsule opacity, or a retinal disease is the cause of the problem.
- Glare, halos, and reduced contrast sensitivity can occur after multifocal intraocular lens implant. Most of these symptoms get better within a few months possibly due to neuroadaptation [12]. It would be there for wise to wait for a few months until we are sure that the manifest refraction is stable and neuroadaptation has finished before planning and performing a secondary laser treatment.
- Surface eye diseases and especially dry eye should be looked for and evaluated since corneal laser treatment tends to exacerbate these diseases. Dry eye should be one of the major concerns while considering corneal refractive laser treatment. About 33% of the population report of some dryness filling in their eyes. Since dry eye is known to be a common problem after LASIK, it would be wise to asses this problem and try to solve it prior to the laser treatment. Preventive treatment with lubricants after the laser treatment might be a good practice in patients that already have a tendency toward dry eyes.
- Choosing the adequate laser treatment. There are different types of corneal refractive laser treatments. The surgeon should choose what kind of treatment he should recommend based on the patients' refractive error, clinical situation, corneal thickness and configuration, and patients' needs.
- Residual refractive errors cannot always be treated by one treatment alone. Sometimes there is a need for more than one procedure. The patient should be explained that such a possibility exists and be prepared for it [13].

One of the major issues is when to perform a laser refractive surgery after a cataract surgery with multifocal intraocular lens implant. We know that neuroadaptation is a procedure that takes time – in some cases it may take months. This fact puts the surgeon in a dilemma – is it truly a refractive error or lack of neuroadaptation that causes the patient's problem? There is no stiff guideline in this matter but it may be reasonable to depend on objective measurements like corneal topography and automatic refractors in the first year after cataract surgery in order to find out if the blurry vision is caused because of a mistake or other lens power measurement fault.

If the patient had cataract operation 1 year ago or more, you might be pretty sure that either neuroadaptation has nothing to do with the reduced vision or that it will never occur. In that case there is no use in waiting and a laser refractive surgery is recommended.

If these pretreatment considerations are done, laser refractive treatment is a safe and effective modality for treatment in cases of residual refractive error after multifocal intraocular lenses implant. Treatment of these residual refractive errors requires however experienced and knowledgeable refractive surgeons.

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