

Multifocal Intraocular Lenses: Overview of Their Capabilities, Limitations, and Clinical Benefits

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Multifocal intraocular lenses (IOLs) were introduced more than 20 years ago but have recently gained increasing popularity. On a personal note, I am privileged to be the editor of this special issue of the *Journal of Refractive Surgery* on Multifocal IOLs. I wrote my thesis on multifocal IOLs, 297 pages strong, between 1990 and 1993. At that time, I used the Storz TRUEVISTA bifocal IOL (Bausch & Lomb, Rochester, NY [formerly Storz, St Louis, Mo])¹ and the Alcon AcuraSee bifocal IOL^{2,3} (Alcon Laboratories Inc, Ft Worth, Tex), both three-zone refractive designs with a central and peripheral distance zone and a near annulus. I also used the 3M diffractive bifocal IOL^{2,3} (3M, Minneapolis, Minn), which now is known, after some modifications, as the Alcon ReSTOR multifocal IOL and the AMO Array multifocal IOL (Advanced Medical Optics [AMO], Santa Ana, Calif). Extensive optical tests using modulation transfer function and through-focus response were performed at the Storz optical laboratory in St Louis, Missouri, and I implanted many of those lenses in prospective clinical studies and published the results.¹⁻⁷

With the exception of the AMO Array IOL, none of these lenses was ever marketed in the United States. Most of my publications were never cited again, but it is gratifying when current publications reach the same conclusions as I did approximately 15 years ago.

This special issue of the *Journal* focuses on modern multifocal IOLs. It provides an overview of the most common designs and discusses issues such as what multifocal IOLs can provide, their limitations, and how they can be included in clinical practice to benefit patients.

In-depth information regarding other concepts of presbyopia correction such as monovision or so-called accommodative IOLs has not been included in this issue. However, the article by Patel et al compares multi-

focal IOLs, accommodating IOLs, and presbyLASIK. Monovision remains the most frequently used compromise to address the reading disability caused by presbyopia. Monovision typically provides approximately 1.50 diopters (D) of depth of field. Accommodative IOLs such as the Crystalens (Bausch & Lomb) increase depth of field even more but also use a monovision approach, with one eye being targeted for approximately -1.00 D.

Multifocal IOLs, on the other hand, increase depth of field by creating two or more distinct foci, which has the advantage of excellent near vision and the disadvantage of optical side effects caused by the second image such as halos.

Multifocal IOLs available today use different optical principles and designs. Accordingly, they provide different benefits and limitations. These different optical properties are illustrated by two experimental articles in this issue: Choi and Schwiegerling, who simulated optical performance and night driving with the Alcon ReSTOR, AMO Tecnis multifocal and ReZoom IOLs; and Terwee et al, who used the same IOLs and compared them to monofocal IOLs.

As demonstrated in these articles, diffractive IOLs such as the ReSTOR and Tecnis multifocal, for example, provide two distinct foci, one at near and one at distance, with a visible drop of resolution at intermediate distance. This drop in intermediate vision was also confirmed clinically as shown in the two articles by Goes. Following bilateral implantation of a diffractive multifocal IOL, 7.2% of patients still used spectacles for intermediate distances. Using a "mix & match" approach, which means implanting different IOLs in both eyes, Goes found a higher rate of spectacle independence.

The idea of "mixing & matching" is not a new one, and I am pleased that we could include the paper by Gunenc and Celik who report their long-term experience with this approach. They implanted the Array IOL and the diffractive CeeOn 811E from Pharmacia (Montreal, Quebec, Canada) (no longer available), a predecessor to the Tecnis multifocal IOL. They compared three groups: diffractive IOL and refractive IOL each unilaterally, and both mixed in both eyes of a

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patient. Results were best with the mix & match approach. However, they implanted the first two groups unilaterally only, which biases the results. Interestingly, Gunenc and Celik implanted the diffractive IOL in the dominant eye and the distance-dominant Array IOL in the non-dominant eye. Usually, authors today recommend implanting the distance-dominant IOL in the dominant eye if a mix & match approach is used.

Mixing different multifocal designs is, however, not a generally agreed upon concept. It works clinically in my experience, but there is the risk that patients perceive the difference in vision or optical side effects as bothersome. In the article by Hütz et al, intermediate vision and reading speed were compared with the Array IOL, ReSTOR IOL, and Tecnis multifocal IOL, each implanted bilaterally. The authors observed that reading acuity and reading speed at 60 cm and 80 cm were better with the Tecnis multifocal than with the Array IOL, which contradicts the rationale of mixing different multifocal IOLs. I therefore believe that bilateral implantation of the same design and mixing different designs are viable options. Patient selection is the key. Also, the decision regarding which IOL should be used for the second eye should be based on the results of the first. If the patient is happy with the results in the first eye, the second eye should receive the same IOL design.

The advantage of spectacle independence, or at least significantly reduced spectacle dependence, comes at a price. As outlined by Martínez Palmer et al, monofocal IOLs provide better quality of vision and fewer visual side effects than the several multifocal IOLs tested. Patient selection is therefore an important issue. Put simply, a multifocal IOL is a great IOL for patients who do not like to wear spectacles and are willing to endure side effects such as halos.

Is the patient's quality of life improved with multifocal IOLs? This issue was addressed by Blaylock et al, who evaluated quality of life after bilateral implantation of a ReSTOR IOL and reported improvement of vision-related quality of life, which was most evident in hyperopes. This supports the claim that multifocal IOLs present a valuable option in patients who do not want to wear spectacles.

Another important conclusion reported by most of the studies is that emmetropia is critical to a good performance of multifocal IOLs. As emmetropia cannot be achieved in all patients by lens surgery alone, additional laser vision correction is required in a certain number of patients. Should the laser treatment be based on residual refraction or should customized ablation be used?

Jendritza and myself performed wavefront-guided

ablations in patients with different multifocal IOLs. We found that this approach worked well in diffractive multifocal IOLs (Tecnis multifocal and ReSTOR) but should not be used in refractive multifocal IOLs (ReZoom). These clinical results are explained by the imaging properties of the different multifocal IOLs, which were demonstrated by Campbell. He performed wavefront measurements in an artificial eye and found that diffractive IOLs could be measured reliably whereas refractive multifocal IOLs could not. Our results were also supported by Charman et al, who were able to perform aberrometry with the ReSTOR IOL reliably in most eyes using a different aberrometer than the one we used. However, Charman et al also reported difficulties performing aberrometry with diffractive contact lenses and caution that aberrometry should be used with care even in diffractive multifocal IOLs.

Is customized ablation needed in multifocal IOLs? A recent study by MacRae⁸ found that subjective complaints and poor distance vision were correlated to corneal coma, trefoil, and spherical aberration as well as coma caused by IOL decentration. MacRae used high-resolution aberrometry as well as corneal wavefront analysis. His results indicate that wavefront analysis is important to both diagnose vision and to treat residual ametropia and higher order aberrations in eyes with multifocal IOLs. Current aberrometry is still not able to measure all IOL designs and all eyes, but customized ablations should continue to be evaluated in eyes with multifocal IOLs.

As a final issue, most authors report considerable neuroadaptation after the implantation of multifocal IOLs. Patients have to adjust to multifocality and their vision will improve over time. We usually address neuroadaptation by advising our patients to be patient. Can we do better? In this context, Kaymak et al present the idea of training visual performance. Their article reports a lasting effect of short-term training on visual performance. Although the number of patients included in the study is small, it is an interesting idea.

The correction of presbyopia is the final challenge to refractive surgery. Multifocal IOLs offer a useful compromise and are here to stay until a means to restore the accommodation of the human lens is discovered.

REFERENCES

1. Knorz MC, Aron-Rosa D, Claessens D, Seiberth V, Münch D. Vision with the TRUE VISTA bifocal IOL. *European Journal of Implantation and Refractive Surgery*. 1992;4:95-98.
2. Knorz MC, Bedoya JH, Hsia TC, Neubert WJ, Jones M, McCary BD, Seiberth V, Liesenhoff H. Comparison of modulation transfer function and through focus response with monofocal and bifocal IOLs. *German Journal of Ophthalmology*. 1992;1:45-53.

3. Knorz MC. Vision with bifocal intraocular lenses. *German Journal of Ophthalmology*. 1993;2:32-41.
4. Knorz MC, Liesenhoff H. Indications and contraindications for implantation of bifocal intraocular lenses [German]. *Klin Monatsbl Augenheilkd*. 1993;202:500-506.
5. Knorz MC. Results of a European multicenter study of the True Vista bifocal intraocular lens. *J Cataract Refract Surg*. 1993;19:626-634.
6. Knorz MC, Claessens D, Schaefer RC, Seiberth V, Liesenhoff H. Evaluation of contrast acuity and defocus curve in bifocal and monofocal intraocular lenses. *J Cataract Refract Surg*. 1993;19:513-523.
7. Knorz MC. A theoretical model to predict contrast sensitivity with bifocal intraocular lenses. *German Journal of Ophthalmology*. 1994;3:189-194.
8. MacRae S. Wavefront profiles of higher order aberration in ReSTOR and ReZoom multifocal intraocular lenses. Presented at: OSN Hawaiian Eye 2008; January 19-25, 2008; Kona, Hawaii.