Clear-Lens Extraction with Multifocal Lens Implantation

I. Howard Fine, M.D.
Richard S. Hoffman, M.D.
Mark Packer, M.D.

The options for treating the refractive surgery patient are greater now than at any time in ophthalmic history. Although excimer laser refractive surgery is growing in popularity, it has limitations in treating extreme degrees of myopia and hyperopia. In addition, presbyopic patients undergoing corneal refractive surgery must rely on reading glasses or monovision to obtain the full range of visual function.

We have found an increased use and success for clear-lens replacement and multifocal intraocular lens (IOL) implantation in our practice. High hyperopes, presbyopes, and patients who have borderline cataracts and have presented for refractive surgery have been ideal candidates for this new technology.

Multifocal IOL technology offers patients substantial benefits. The elimination of a presbyopic condition and restoration of normal vision by simulating accommodation greatly enhances the quality of life for most patients. The only multifocal IOL available for general use in the United States is the AMO Array (Allergan Surgical Products, Irvine, CA). The advantages of astigmatically neutral clear corneal cataract surgery have allowed for increased use of multifocal technology in both cataract and clear-lens replacement surgery. Careful attention to patient selection, preoperative biometry and lens power calculations, and meticulous surgical technique will allow surgeons to offer multifocal technology to their patients with great success.

■ Lens Design

The principle of any multifocal design is to create multiple image points behind the lens. The goal of these lenses is to enable less reduction

in visual acuity for a given amount of defocus by improving the depth of field. The AMO Array is a zonal progressive IOL with five concentric zones on the anterior surface (Figure). Zones 1, 3, and 5 are distance dominant zones, whereas zones 2 and 4 are near dominant. The lens has an aspherical component; thus, each zone repeats the entire refractive sequence corresponding to distance, intermediate, and near foci. This results in vision over a range of distances. The lens uses 100% of the incoming available light and is weighted for optimum light distribution. With typical pupil sizes, approximately one-half of the light is distributed for distance, one-third for near vision, and the remainder for intermediate vision. The lens uses continuous surface construction; consequently, no light is lost through defraction, and no degradation of image quality occurs as a result of surface discontinuities. The lens has a foldable silicone optic that is 6.0 mm in diameter, with haptics made of polymethyl methacrylate and a haptic diameter of 13 mm. The lens can be inserted through a clear corneal or scleral tunnel incision that is 2.8 mm wide, using the Unfolder injector system manufactured by AMO (Allergan Surgical).

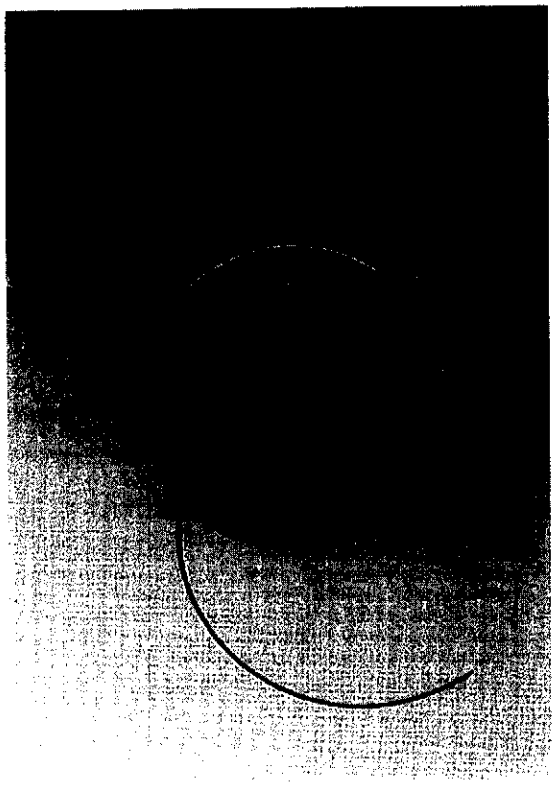

Figure 1. *The AMO Array foldable silicone multifocal intraocular lens.*

■ Clinical Results

The efficacy of multifocal technology has been documented in many clinical studies. Early studies of the one-piece AMO Array documented a larger percentage of patients who were able to read J2 print after undergoing multifocal lens implantation as compared to patients with monofocal implants.[1–3] Similar results have been documented for the foldable AMO Array.[4] Clinical trials comparing multifocal lens implantation and monofocal lens implantation in the same patient also revealed improved intermediate and near vision in the multifocal eye as compared to the monofocal eye.[5,6]

Many studies have evaluated both the objective and subjective qualities of contrast sensitivity, stereoacuity, glare disability, and photic phenomena after implantation of multifocal IOLs. Refractive multifocal IOLs, such as the Array, were found to be superior to diffractive multifocal IOLs by demonstrating better contrast sensitivity and less glare disability.[7] The Array does produce a small amount of contrast sensitivity loss equivalent to the loss of 1 line of visual acuity at the 11% contrast level using Regan contrast sensitivity charts.[2] This loss of contrast sensitivity at low levels is present only when the Array is placed monocularly and has not been demonstrated with bilateral placement and binocular testing.[8] In addition to relatively normal contrast sensitivity, good random-dot stereopsis and less distance and near aniseikonia were present in patients with bilateral placement as compared to those receiving unilateral implants.[9]

One of the potential drawbacks of the Array lens has been the potential for an appreciation of halos around point sources of light at night in the early weeks and months after surgery.[10] Most patients will learn to disregard these halos with time, and bilateral implantation appears to improve these subjective symptoms. Concerns about the visual function of patients at night have been allayed by a driving simulation study in which bilateral Array multifocal patients performed only slightly worse than did patients with bilateral monofocal IOLs. The results indicated no consistent difference in driving performance and safety between the two groups.[11] In a study by Javitt and coworkers,[12] 41% of bilateral Array implantation subjects were found never to require spectacles, compared to 11.7% of monofocal controls. Overall, subjects with bilateral Array IOLs reported better overall vision, less limitation in visual function, and less use of spectacles than did monofocal controls.

A small study performed within our practice reviewed the clinical results of our first 50 patients with implanted bilateral Array multifocal lenses. When tested bilaterally, one-half of the patients were able to see 20/30 and Jaeger 3 print. Ninety-two percent were able to see 20/40 and Jaeger 4 print. All 50 patients were able to read 20/40 and Jaeger 5 print. We consider these results to be excellent.

■ Patient Selection

Our use of the Array multifocal IOL over the last 2.5 years has been extensive. We have used this device in approximately 30% of our cataract patients and in the majority of our clear-lens replacement refractive surgery patients. As a result of our experience, we have developed specific guidelines with respect to the selection of candidates and surgical strategies that enhance outcomes with this IOL.

AMO recommends using the Array multifocal IOL for bilateral cataract patients whose surgery is uncomplicated and whose personality is such that they are not likely to fixate on the presence of minor visual aberrations, such as halos around lights. Obviously, a broad range of patients would be acceptable candidates. Relative or absolute contraindications include the presence of ocular pathologies (other than cataracts) that may degrade image formation or may be associated with less than adequate visual function postoperatively despite visual improvement after surgery. Preexisting ocular pathologies that are frequently viewed as contraindications include age-related macular degeneration, uncontrolled diabetes or diabetic retinopathy, uncontrolled glaucoma, recurrent inflammatory eye disease, retinal detachment risk, and corneal disease or previous refractive surgery in the form of radial keratotomy, photorefractive keratectomy, or laser assisted in situ keratomileusis. However, a recent study has revealed comparable distance acuity outcomes in Array and monofocal patients with concurrent eye disease, such as macular degeneration, glaucoma, and diabetic retinopathy.[13]

We avoid the use of these lenses in patients who complain excessively, are highly introspective and fussy, or obsess over body image and symptoms. We are conservative when evaluating patients with occupations that include frequent night driving and those that put high demands on vision and near work, such as engineers and architects. Such patients need to demonstrate a strong desire for relative spectacle independence to be considered for Array implantation.

In our practice, we have reduced patient selection to a very rapid process. Once we determine that someone is a candidate for either cataract extraction or clear-lens replacement, we ask the patient two questions. The first question is, "if we could put an implant in your eye that would allow you to see both distance and near without glasses, under most circumstances, would that be an advantage?" Approximately 50% of our patients say no in one way or another. Those negative responses may include "I don't mind wearing glasses," "My grandchildren wouldn't recognize me without glasses," "I look terrible without glasses," or "I've worn glasses all my life." These patients receive monofocal IOLs. For the 50% who say it would be an advantage, we ask a second question: "If the lens is associated with halos around lights at night, would it still be an advantage?" Approximately 60% of this group of patients say that they do not

think they would be bothered by these symptoms, and they receive a multifocal IOL.

In special circumstances, implantation of a multifocal IOL should be strongly considered. Alzheimer's patients frequently lose or misplace their spectacles; thus, they might benefit from the full range of view that a multifocal IOL provides without spectacles. Patients with arthritis of the neck or other conditions with limited range of neck motion may benefit from a multifocal IOL rather than multifocal spectacles that require changes in head position. Patients with a monocular cataract who successfully have worn monovision contact lenses should be considered possible candidates for monocular implantation. The same is true for certain occupations, such as photographers who want to alternate focusing through the camera without spectacles and adjust imaging parameters on the camera without putting spectacles on; in these patients, the focusing eye could have a monofocal IOL and the nondominant eye a multifocal. We almost always use the Array in traumatic cataracts in young adults to facilitate binocularity at near, especially if the fellow eye has no refractive error or is corrected by contact lenses.

Prior to implanting an Array, we inform all candidates of the lens's statistics to ensure that they understand that spectacle independence is not guaranteed. Approximately 41% of the patients with implanted bilateral Array IOLs never will need to wear glasses, 50% wear glasses on a limited basis (such as driving at night or during prolonged reading), 12% always will need to wear glasses for near work, and approximately 8% will need to wear spectacles on a full-time basis for distance and near correction.[11] In addition, 15% of patients were found to have difficulty with halos at night, and 11% had difficulty with glare as compared to 6% and 1%, respectively, in monofocal patients.

■ Preoperative Measurements

The most important assessment for successful multifocal lens use, other then patient selection, involves precise preoperative measurements of axial length in addition to accurate lens power calculations. Some practitioners think that immersion biometry is necessary for accurate axial length determination. However, in our practice, we have found applanation techniques in combination with the Holladay 2 formula to yield accurate and consistent results with greater patient convenience and less technician time. We are experimenting with the Zeiss IOLMaster for noncontact optical measurements. The IOLMaster is a combined biometry instrument for the measurement of axial length, corneal curvature, and anterior chamber depth. The axial length measurement is based on an interference-optical method termed partial *coherence interferometry*. Measurements are claimed to be compatible with acoustic immersion mea-

surements and accurate to within 30 μm. This new technology offers the possibility of extremely accurate and efficient measurements with minimal patient inconvenience.

In determining lens power calculations, the Holladay 2 formula takes into account disparities in anterior segment and axial lengths by adding the white-to-white corneal diameter and lens thickness into the formula. Addition of these variables helps to predict the exact position of the IOL in the eye and has improved refractive predictability. As a final check in the lens power assessment, we also will use the SRK T and the SRK II formulas and, for eyes with less than 22 mm in axial length, the Hoffer Q formula for comparative purposes.

■ Surgical Technique

The multifocal Array works best when the final postoperative refraction has less than 1D of astigmatism. It is, thus, very important that incision construction be appropriate with respect to size and location. We favor a clear corneal incision at the temporal periphery that is 3 mm or less in width and 2 mm long.[14] Surgeons should be aware of their usual amount of surgically induced astigmatism by vector analysis. Surgeons also must be able to use one of the many modalities for addressing preoperative astigmatism. Although we have used both T and arcuate keratotomies at the 7-mm optical zone, we currently favor limbal relaxing incisions[15,16] using a Force blade (Mastel Precision Surgical Instruments, Rapid City, SD) and a Nichamin nomogram.

In preparation for phacoemulsification, the capsulorhexis must be round and sized so that a small margin of anterior capsule overlaps the optic circumferentially. This is important to guarantee in-the-bag placement of the IOL and to prevent anterior-posterior alterations in location that would affect the final refractive status. Hydrodelineation and cortical-cleaving hydrodissection are very important in all patients because they facilitate lens disassembly and complete cortical cleanup.[17] Complete and fastidious cortical cleanup will, it is hoped, reduce the incidence of posterior capsule opacification the presence of which, even in very small amounts, will degrade inordinately the visual acuity in Array patients. Because of this phenomena, patients with implanted Array lenses will require YAG laser posterior capsulotomies earlier than will patients with monofocal IOLs.

Minimally invasive surgery is very important. Techniques that produce effective phacoemulsification times of less than 20 seconds and average phacoemulsification powers of 10% or less are highly advantageous and can be achieved best with power modulations (burst mode or 2 pulses per second) rather than continuous phacoemulsification modes.[18] The Array is inserted easiest by means of the Unfolder injector system. Complete

removal of all viscoelastic from the anterior chamber and behind the lens will reduce the incidence of postoperative pressure spikes and myopic shift from capsular block syndrome.

■ Management of Complications

When intraoperative complications develop, they must be handled precisely and appropriately. In situations in which the first eye already has had an Array implanted, complication management must be directed toward finding any possible way of implanting an Array in the second eye. Under most circumstances, capsule rupture still will allow for implantation of an Array as long as an intact capsulorhexis exists. Under these circumstances, the lens haptics are implanted in the sulcus, and the optic is prolasped posteriorly through the anterior capsulorhexis. This is facilitated by a capsulorhexis that is slightly smaller than the diameter of the optic to capture the optic in essentially an in-the-bag location. If full sulcus implantation is used, appropriate change in the IOL power will have to be made to compensate for the more anterior location of the IOL within the eye. When vitreous loss occurs, a meticulous vitrectomy with clearing of all vitreous strands must be performed.

It is important to avoid iris trauma, because the pupil size and shape may have an impact on the visual function of a multifocal IOL postoperatively. If the pupil is less than 2.5 mm, an impairment of near visual acuity may be possible, owing to the location of the rings serving near visual acuity. For patients with small postoperative pupil diameters affecting near vision, we have had success using the Argon laser to perform a mydriatic pupilloplasty.[19]

■ Postoperative Course

If glasses are required after surgery, the spherical correction should be determined by overplusing the patient to a slight blur and gradually reducing the power until the best acuity is reached. Patients are able to focus through the near portions of their IOL; thus, it is possible to overminus a patient if care is not taken to push the plus power. When using this defocusing technique, it is critical to stop as soon as distance acuity is maximized, to avoid over-minusing. The cylinder power should be the smallest amount that provides the best acuity. If add power is necessary, the full add power for the required working distance should be prescribed.

If patients are unduly bothered by photic phenomena, such as halos and glare, these symptoms can be alleviated by various techniques. Weak pilocarpine at a concentration of 1/8% or weaker will constrict the pupil

to a diameter that will usually lessen the severity of halos without significantly effecting near visual acuity. Another approach involves the use of over-minused spectacles to push the secondary focal point behind the retina and thus lessen the effect of image blur from multiple images in front of the retina. Polarized lenses also have been found to be helpful in reducing photic phenomena. Perhaps the most important technique is the implantation of bilateral Array lenses as close in time as possible to allow patients the ability to use the lenses together, which appears to allow for improved binocular distance and near vision as compared to monocular acuity. Finally, most patients report that halos improve or disappear with the passage of several weeks to months.

■ Summary

We have had a great deal of success with the Array multifocal IOL in patients undergoing cataract and refractive surgery. We recognize that multifocal technology is not for every patient considering refractive surgery but does offer substantial benefits, especially in high hyperopes, presbyopes, and patients who have borderline or soon to be clinically significant cataracts and are requesting refractive surgery. Appropriate patient screening, accurate biometry and lens power calculations, and meticulous surgical technique will allow surgeons to maximize their success with this lens. As with any new technology, there is a learning curve to its use, and we believe that the information provided in this chapter will be helpful in mastering its use.

■ References

1. Percival SPB, Setty SS. Prospectively randomized trial comparing the pseudoaccommodation of the AMO Array multifocal lens and a monofocal lens. J Cataract Refract Surg 1993;19:26–31
2. Steinert RF, Post CT, Brint SF, et al. A progressive, randomized, double-masked comparison of a zonal-progressive multifocal intraocular lens and a monofocal intraocular lens. Ophthalmology 1992;99:853–861
3. Negishi K, Nagamoto T, Hara E, et al. Clinical evaluation of a five-zone refractive multifocal intraocular lens. J Cataract Refract Surg 1996;22:110–115
4. Brydon KW, Tokarewicz AC, Nichols BD. AMO Array multifocal lens versus monofocal correction in cataract surgery. J Cataract Refract Surg 2000;26:96–100
5. Vaquero-Ruano M, Encinas JL, Millan I, et al. AMO Array multifocal versus monofocal intraocular lenses: long-term follow-up. J Cataract Refract Surg 1998;24:118–123
6. Steinert RF, Aker BL, Trentacost DJ, et al. A prospective study of the AMO Array zonal-progressive multifocal silicone intraocular lens and a monofocal intraocular lens. Ophthalmology 1999;106:1243–1255
7. Pieh S, Weghaupt H, Skorpik C. Contrast sensitivity and glare disability with diffractive and refractive multifocal intraocular lenses. J Cataract Refract Surg 1998;24:659–662
8. Arens B, Freudenthaler N, Quentin CD. Binocular function after bilateral implantation

of monofocal and refractive multifocal intraocular lenses. J Cataract Refract Surg 1999; 25:399–404
9. Haring G, Gronemeyer A, Hedderich J, de Decker W. Stereoacuity and aniseikonia after unilateral and bilateral implantation of the Array refractive multifocal intraocular lens. J Cataract Refract Surg 1999;25:1151–1156
10. Dick HB, Krummenauer F, Schwenn O, et al. Objective and subjective evaluation of photic phenomena after monofocal and multifocal intraocular lens implantation. Ophthalmology 1999;106:1878–1886
11. Featherstone KA, Bloomfield JR, Lang AJ, et al. Driving simulation study: bilateral array multifocal versus bilateral AMO monofocal intraocular lenses. J Cataract Refract Surg 1999;25:1254–1262
12. Javitt JC, Wang F, Trentacost DJ, et al. Outcomes of cataract extraction with multifocal intraocular lens implantation—functional status and quality of life. Ophthalmology 1997;104:589–599
13. Kamath GG, Prasas S, Danson A, Phillips RP. Visual outcome with the Array multifocal intraocular lens in patients with concurrent eye disease. J Cataract Refract Surg 2000; 26:576–581
14. Fine IH. Corneal tunnel incision with a temporal approach. In: Fine IH, Fichman RA, Grabow HB, eds. Clear-corneal cataract surgery and topical anesthesia. Thorofare, NJ: Slack, Inc, 1993:5–26
15. Gills JP, Cayton JL. Reducing pre-existing astigmatism. In: Cataract surgery: the state of the art. Thorofare, NJ: Slack, Inc, 1998:53–66
16. Nichamin L. Refining astigmatic keratotomy during cataract surgery. Ocular Surg News April 15, 1993
17. Fine IH. Cortical cleaving hydrodissection. J Cataract Refract Surg 1992;18:508–512
18. Fine IH. The choo-choo chop and flip phacoemulsification technique. Opera Techn Cataract Refract Surg 1998;1(2):61–65
19. Thomas JV. Pupilloplasty and photomydriasis. In: Belcher CD, Thomas JV, Simmons RJ, eds. Photocoagulation in glaucoma and anterior segment disease. Baltimore: Williams & Wilkins, 1984:150–157