Phakic IOLs are placed in the eyes of patients with normal crystalline lenses. There are many different styles, generally referred to depending on the site of fixation: anterior chamber angle, iris surface, and posterior chamber ciliary sulcus. Currently, phakic IOLs occupy a growing niche in the field of refractive surgery; they represent safe and effective alternatives to laser corneal procedures.

I was invited as the guest medical editor of this issue after I suggested phakic IOLs as a topic for coverage in 2010. The articles in this cover series are designed to pique the interest of surgeons who are not yet using phakic IOLs as well as to explore surgical pearls and special indications for implantation for surgeons who are already equipped with this refractive tool in their armamentarium. This introduction provides an overview of the history and current indications associated with phakic IOLs. Table 1 lists the available models as well as phakic IOLs in development (information from Market Scope), including the main characteristics of each lens.

It is important for surgeons to present phakic IOLs as an option to patients at the same time LASIK is discussed. It is key to focus on the reversibility of this refractive surgical procedure and its ability to preserve the normal shape of the cornea without inducing optical aberrations. This strategy provides patients with a higher quality of vision.

HISTORY

Phakic IOLs were introduced during the 1950s by talented surgeons such as Benedetto Strampelli, MD, of Italy; M. Dannheim, MD, of Germany; and José Ignacio Barraquer, MD, of Spain. These anterior chamber lenses were abandoned when complications such as corneal edema, chronic uveitis, iris atrophy, cataract, and glaucoma were observed. Such side effects were related to the poor quality of materials and manufacturing and the absence of adequate microsurgical techniques and ophthalmic viscosurgical devices.

Since the late 1980s, there has been a renaissance of interest in phakic IOLs. Many models have been developed from the original ideas of P.U. Fechner, MD, of Germany, and Jan G.F. Worst, MD, of Holland, who codeveloped the iris-claw; Georges Baikoff, MD, of France, who developed four-point angle fixation; and Svyatoslav Fyodorov, MD, of Russia, who developed the plate design for sulcus fixation.

In 2007, the French Products Safety Agency (AFSSAPS) withdrew two angle-supported phakic IOLs, the Vivarte NewLife (IOLtech, La Rochelle, France/Carl Zeiss Meditec, Jena, Germany), and iCare (Corneal, Paris), because of sudden endothelial cell loss observed 2 to 3 years after implantation. However, there are many valid phakic IOLs on the market today that have alternative sites of fixation. Table 2 summarizes the main advantages of modern phakic IOLs.

PERSONAL EXPERIENCE

In my experience, which includes implantation of more than 600 Visian ICLs (STAAR Surgical, Monrovia, California), I routinely include phakic IOLs as one consideration for any patient looking for a surgical solution to refractive error.

I started implanting myopic ICLs 10 years ago, and the number of implants has increased due to indications for hyperopia and associated astigmatism with the introduction of hyperopic and toric models.

Phakic IOLs should be considered as an alternative or complementary procedure to the various laser options available today. Standard myopic, hyperopic, and astigmatic cases can benefit from the excellent performance of these lenses. I have also found that phakic IOLs are the better approach to refractive correction in previously altered corneas. Patients with irregular astigmatism due...
## TABLE 1. PHAKIC IOLs AVAILABLE AND IN DEVELOPMENT

<table>
<thead>
<tr>
<th>Lens</th>
<th>Manufacturer</th>
<th>Material</th>
<th>Placement</th>
<th>Optic diameter and lens design</th>
<th>Total length</th>
<th>Power ranges</th>
<th>Incision size</th>
</tr>
</thead>
<tbody>
<tr>
<td>AcrySof Cachet</td>
<td>Alcon Laboratories, Inc.</td>
<td>Hydrophobic acrylic</td>
<td>AC† (angle-supported)</td>
<td>6.0 mm optic; Four-point haptics are designed for flexible but firm fixation</td>
<td>12.5 to 14.0 mm</td>
<td>-6.00 to -16.50 D (0.50 D increments)</td>
<td>2.6 mm</td>
</tr>
<tr>
<td>Phakic Refractive Lens (PRL)</td>
<td>Carl Zeiss Meditec/IOLTech</td>
<td>Silicone</td>
<td>PC†</td>
<td>4.5 mm; Plate style haptics; Myopic model is bi-concave</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Vision Membrane</td>
<td>Hoya/VMT</td>
<td>Acrylic</td>
<td>AC</td>
<td>Ultra-thin anterior chamber angle-supported IOL with diffractive multifocal optic</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>LN-2000</td>
<td>Lenstec</td>
<td>SP silicone</td>
<td>AC (angle-supported)</td>
<td>5.0 mm; Four-point fixed haptics and one-piece construction</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Type 99-C</td>
<td>Morcher</td>
<td>SP silicone</td>
<td>AC (angle-supported)</td>
<td>5.3 mm; Four-point fixed haptics</td>
<td>13.0 mm</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Artiflex/Veriflex</td>
<td>Ophtec BV/Abbott Medical Optics Inc.</td>
<td>Silicone optic and PMMA haptics</td>
<td>AC (iris-fixed)</td>
<td>6.0 mm; Foldable version of the Artisan/Verisyse</td>
<td>8.5 mm</td>
<td>-2.00 to -14.50 D (0.50 D increments)</td>
<td>3.2 mm</td>
</tr>
<tr>
<td>Toric Artiflex/Veriflex</td>
<td>Ophtec BV/Abbott Medical Optics Inc.</td>
<td>Silicone optic and PMMA haptics</td>
<td>AC (iris-fixed)</td>
<td>6.0 mm; Foldable version of the Artisan/Verisyse</td>
<td>8.5 mm</td>
<td>-1.00 to -13.50 D sphere; -1.00 to -5.00 D cylinder (0.50 D increments)</td>
<td>3.2 mm</td>
</tr>
<tr>
<td>Artisan/Verisyse myopia</td>
<td>Ophtec BV/Abbott Medical Optics Inc.</td>
<td>PMMA</td>
<td>AC (iris-fixed)</td>
<td>5.0 mm or 6.0 mm; Rigid optic with enclavation haptics</td>
<td>8.5 mm</td>
<td>-1.00 to -23.50 D (0.50 D increments)</td>
<td>5.0 mm or 6.0 mm</td>
</tr>
<tr>
<td>Artisan/Verisyse hyperopia</td>
<td>Ophtec BV/Abbott Medical Optics Inc.</td>
<td>PMMA</td>
<td>AC (iris-fixed)</td>
<td>5.0 mm</td>
<td>8.5 mm</td>
<td>1.00 to 12.00 D (0.50 D increments)</td>
<td>5.0 mm</td>
</tr>
</tbody>
</table>
to previous surgery are contraindicated for laser vision correction or incisional corneal surgery, but they can benefit from this technique. Additionally, I use phakic IOLs in the presence of trauma (Figure 1), leukomas and scars, keratoconus, and thin corneas. I also use them in patients who previously have undergone radial keratotomy.

Our incidence of cataract as a result of phakic IOL implantation is 0.8%. In these cases, the ICL was removed and cataract surgery with IOL implantation was performed. Patients’ original BCVA was maintained. Other complications in our practice have included a 2.4% incidence of pupillary block, which has decreased to 0% since we changed from Nd:YAG laser iridotomy to surgical iridectomy.

I have seen only a single case of endophthalmitis. We must keep in mind that this is an intraocular surgical procedure, and all efforts should be made to avoid this type of infrequent but unpredictable and potentially dreadful complication. Therefore, as we routinely do with cataract surgery, we have introduced the use of intracameral cefuroxime at the end of phakic IOL implantation surgery.

Available 10-year follow-up data (on file with STAAR Surgical).
Surgical show that the human eye tolerates most models of these lenses. Studies carried out by the Spanish ICL Study Group, in which I am a participant, have demonstrated the same for the posterior chamber Visian ICL. At 7-year follow-up, outcomes are available for 4,513 eyes with myopia and astigmatism. Retrospective analysis showed excellent and stable visual and refractive results, with a low rate of complications in line with those from clinical trials for US Food and Drug Administration (FDA) approval of the myopic ICL (unpublished data; Figure 2).

ASSOCIATED COMPLICATIONS

As with any surgical procedure, complications can occur; however, good candidate selection and evaluation and a proper surgical technique allow one to avoid the majority of complications and diminish their incidence to low rates. Additionally, residual refractive errors can be easily treated with phakic IOL exchange or laser surgery (ie, bioptics). Complications that are associated with the
Cover Story

Use of phakic IOLs include endothelial damage, decentration, pupil ovalization, pigmentary glaucoma, cataract, and iridocyclitis. The following is a list of how each affects the procedure:

- Endothelial damage related to the lens is minimal and within a tolerable range with modern anterior chamber phakic lenses and virtually insignificant with posterior chamber models.
- Decentration can be solved by phakic IOL exchange and sizing adjustments if it is clinically significant.
- Pupil ovalization is caused by the footplates of angle-supported lenses coming into contact with the peripheral iris.
- Pigmentary glaucoma can appear due to iris chafing.
- Cataract is related to damage of the crystalline lens during lens insertion. Alternatively, it may be due to alteration in the metabolism of the anterior capsule and cortex or close contact between the phakic IOL and the lens that increases with age and accommodation.
- Iridocyclitis and pigment dispersion can be observed generally with little clinical consequence.

Ideal Patients and Surgical Considerations

The ideal candidate for phakic IOL surgery should be between the ages of 25 and 45 years with normal endothelial cell count (more than 2,000 cells/mm²) and sufficient anterior chamber depth. We always recommend evaluating this option before considering refractive lens exchange. In patients over the age of 45 to 50 years, we usually consider clear lens surgery options.

Preoperative evaluation is similar to that for any other refractive surgery. Modern imaging technologies such as Scheimpflug-based devices, optical coherence tomography, and anterior segment ultrasound should be incorporated to achieve a better understanding of the patient’s anterior segment dynamic anatomy. Some additional exclusion criteria are derived from anterior segment imaging studies, such as an internal diameter less than 11.5 mm, greater than 300 µm crystalline lens rise over the pupil line, or an ideal vault that is approximately 20% of the total anterior chamber depth. High-powered lenses should be avoided because of their thicker edges.

Sizing is possibly the most important issue related to phakic IOLs. Modern imaging systems should replace subjective white-to-white measurements, and different options must be always be evaluated, including the one-size-fits-all concept of iris-fixated lenses or the new solution of an angle-supported phakic lens with flexible and adaptable haptics (AcrySof Cachet; Alcon Laboratories, Inc., Fort Worth, Texas).

Conclusion

We still do not completely understand how phakic IOLs interact with the crystalline lens, iris, angle, and endothelium with regard to the proximity of the lens. However, the excellent clinical and visual results are encouraging, and these lenses have a widening range of indications. The phakic IOL solution is becoming more common for many refractive problems. In the past 10 years, its use has grown to the point where it is now considered a standard procedure for the comprehensive refractive surgeon (Figure 3).

I would like to thank the contributing authors in this cover focus for providing valuable and expert information in this exciting field of phakic lenses. I also would like to thank Laura Straub and the staff of CRST Europe for their kind support and for accepting the idea of a cover focus dedicated to phakic IOLs.

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Table 2. Advantages of Modern Phakic IOLs

- Normal corneal curvature and unaltered corneal shape
- Preservation of accommodation
- Reversible procedure (easy to remove/replace)
- Phakic IOL power calculations are accurate and easy
- Stable final refractive result
- High efficacy and safety indices
- Minimal up-front investment
- Surgical skills similar to cataract surgery
- Suitable for different types of refraction and for a wide range of diopters

Take-Home Message

- Phakic IOLs should be considered as an alternative or complementary procedure to the various options for laser vision correction.
- Intracameral cefuroxime can be introduced to prevent endophthalmitis in the same fashion as for cataract surgery.
- Proper patient selection and evaluation and a good surgical technique decrease the rate of complications associated with phakic IOLs.
- Consider the use of phakic IOL implantation before refractive lens exchange if the patient is between 25 and 45 years of age.