Phakic IOLs: An Overview

These lenses are fundamental tools in a successful refractive surgery practice.

BY ANTÓNIO MARINHO, MD, PhD

The aim of refractive surgery is to modify the refractive power of the eye in a permanent and stable way. There are two main refractive structures in the eye: the cornea and the natural lens. Changing the shape and thickness of the cornea by laser or cataract surgery, or exchanging the natural lens for an IOL, allows us to achieve the aim of refractive surgery. However, there is another possibility: introduction of a new refractive surface in the eye without touching the cornea or the natural lens. This is the concept behind phakic IOLs. This article addresses four questions: (1) Why implant phakic IOLs? (2) When should phakic IOLs be implanted? (3) Which phakic IOL should be implanted? and (4) How should a phakic IOL be implanted?

**QUESTION NO. 1: WHY IMPLANT?**

Laser corneal surgery changes the shape and thickness of the cornea to achieve a refractive correction. If this change is limited (up to -6.00 D in myopia and 3.50 D in hyperopia), there will be a stable result. But if we correct more significant ametropias, factors associated with corneal biomechanics and wound healing can lead to regression and corneal instability. Additionally, the abnormal corneal shape created by laser ablation can result in poor quality of vision, as demonstrated by ray-tracing studies.1,2 On the other hand, lens surgery is not associated with problems of regression or limited by the amount of ametropia correction. However, loss of accommodation in younger patients is an important issue that even modern accommodating or multifocal IOLs cannot solve, as they are unable to match the quality of vision of young eyes.

Phakic IOLs are important tools in refractive surgery; they can be used to accurately and stably correct high ametropias because they are not associated with wound healing and they preserve the natural accommodation of the eye.

**QUESTION NO. 2: WHEN TO IMPLANT?**

The general indications for phakic IOL implantation are myopia greater than -6.00 D, hyperopia greater than 3.50 D, stable refraction (for at least 18 months), age between 18 and 45 years, and a healthy eye. In special circumstances, these criteria can be slightly adapted. In patients with myopia, phakic IOLs may be the procedure of choice for lower degrees if the cornea is too thin (less than 480 μm) or if some form of ectac-
pupil distortion and iris atrophy, caused by a too-large IOL, may result. Likewise, sulcus-fixated posterior chamber phakic IOLs must be appropriately sized to avoid touching the natural lens, leading to cataract development, caused by a too-small IOL, or pushing the iris forward and closing the angle, caused by a too-large IOL. Concerning this problem, iris-fixated phakic IOLs offer the advantage of being one-size-fits-all.

Classically, to determine the angle-to-angle and sulcus-to-sulcus distances, the white-to-white measurement was calculated with calipers or with instruments such as the Orbscan, Pentacam, or IOLMaster. However, this measurement does not always correlate with intraocular distances, leading to errors in IOL sizing. Nowadays, at least for angle-supported anterior chamber phakic IOLs, OCT provides an accurate in vivo measurement of the angle-to-angle distance. High-frequency ultrasound is the procedure of choice to measure the sulcus-to-sulcus distance.

Although in most eyes the iris is flat, in some (mostly hyperopic) eyes the iris is somewhat convex. These eyes are not suitable for implantation of iris-fixated phakic IOLs. OCT is the most reliable method to assess iris configuration.

Pupil size is another important factor for phakic IOL implantation. The rule is that the mesopic pupil size should not be more than 1.00 mm larger than the optic of the phakic IOL.

A healthy endothelium, with a low index of pleomorphism and polymegathism and a cell density of at least 2,200 cells/mm², is also a prerequisite for phakic IOL implantation.

Once all the aforementioned criteria are met, it is necessary to determine the appropriate lens power of the phakic IOL. To do that, the most commonly used formula is one developed by Van der Hejde, which takes into account the spherical equivalent (cycloplegic for hyperopia), anterior chamber depth, and keratometry.

**QUESTION NO. 3: WHICH TO IMPLANT?**

According to their location inside the eye, phakic IOLs can be divided into three groups: (1) anterior chamber angle-supported phakic IOLs (eg, AcrySof Cachet; Alcon), (2) anterior chamber iris-supported phakic IOLs (eg, Artisan and Artiflex [both by Ophtec BV]; also marketed as the Verisyse and Veriflex by Abbott Medical Optics Inc.), and (3) posterior chamber phakic IOLs (eg, Visian ICL; STAAR Surgical).

A variety of phakic IOLs in each of these categories has been available over the past 20 years. Four currently available phakic IOLs are detailed below and in Table 1.

**AcrySof Cachet.** The hydrophobic acrylic AcrySof Cachet (Figure 1) has a 6.00-mm optic and four haptics to ensure angle fixation. It is available only for myopia correction (-6.00 to -16.50 D) and comes in four sizes (12.5 mm, 13.0 mm, 13.5 mm, and 14.0 mm).

**Artisan/Verisyse.** The Artisan lens (Figure 2) is made of PMMA. The optic is 5.00 or 6.0 mm, and the two haptics are shaped like claws to grasp the midperipheral iris tissue. The 5.00-mm Artisan is available for correction of myopia (-2.00 to -23.00 D), hyperopia (2.00 to 12.00 D), and astigmatism (both myopic and hyperopic up to 7.50 D). The 6.00-mm lens is available only for myopia correction (-2.00 to -14.50 D). The overall length of the Artisan is 8.5 mm; because the lens is iris-fixated, there is no need for different sizes.

**Artiflex/Veriflex.** The Artiflex is a foldable lens (Figure 3) with a design similar to the Artisan. It is has a 6.00-mm silicone optic and two PMMA haptics. The overall length is 8.5 mm. The Artiflex is available for the correction of myopia (-2.00 to -14.50 D) and astigmatism (myopic up to -5.00 D, provided that the sphere plus cylinder does not exceed -14.50 D).

**Visian ICL.** The Visian ICL is designed to fit in the ciliary sulcus. It features a plate-haptic design made of the proprietary material Collamer, with an optic diameter of 4.65 to 5.50 mm (myopia, according to power) or 5.50 mm (hyperopia). The Visian ICL is available for correction of myopia (-0.25 to -18.00 D), hyperopia (0.50 to 10.00 D), and, with the brand name Toric ICL, astigmatism (-6.00 to 6.00 D). The ICL comes in four sizes for myopia and astigmatism (12.1, 12.6, 13.2, and 13.7 mm) and four for hyperopia (11.6, 12.1, 12.6, and 13.2 mm). The most recent version, the V4c, has a hole in the middle of the optic for improved aqueous humor flow (Figure 4).
QUESTION NO. 4: HOW TO IMPLANT?

After carefully selecting the patient and the appropriate size and power of the phakic IOL, perfect implantation must be performed to avoid intra- or postoperative complications. The main points of the surgical techniques used with the same four phakic IOLs and the complications most frequently associated with each are detailed below and in Table 2.

**AcrySof Cachet.** Preoperatively, miosis can be achieved using topical pilocarpine 2% applied 15 minutes before surgery or acetylcholine injected intraoperatively. Topical, peribulbar, or general anesthesia can be used, depending on patient and surgeon preference.

The main surgical steps are as follows:

- Create a 1.0-mm sideport incision at the 9-o’clock position (optional);
- Create the main incision (2.6 mm in clear cornea) at the 12-o’clock position;
- Fill the anterior chamber with a cohesive ophthalmic viscosurgical device (OVD);
- Introduce the IOL into the cartridge (cartridge P);
- Introduce the cartridge into the eye and past the iris;
- Inject the IOL slowly, watching it unfold in the right way; note that the small mark on the leading haptic must be on the right, and the one on the trailing haptic on the left;
- Remove the cartridge and introduce the trailing haptics;
- Wash out all of the OVD using I/A or passive irrigation; and
- Close the wound with hydration of the cornea.

There is no need for iridotomy or iridectomy. Postoperative medication includes topical antibiotic (levofloxacin) plus steroid (prednisolone acetate) four times daily for 2 weeks.

With the AcrySof Cachet, most intraoperative complications can be avoided with a carefully performed surgery. Cases of the IOL being implanted upside-down have been described, but this is easily avoided if one pays attention to the position of the haptic marks during unfolding. Although this IOL is relatively new to the market, in clinical study over a 10-year period investigators did not observe the complications that were commonly reported with previous designs of angle-supported phakic IOLs such as iris atrophy or pupil distortion. For a video demonstration of AcrySof Cachet implantation, visit eyetube.net/?v=gaviz.

**Artisan/Verisyse.** For implantation of the this lens, topical pilocarpine 2% applied 15 minutes before surgery or intraoperative acetylcholine can be used for pupil constriction. Topical, peribulbar, or general anesthesia can be used, depending on patient and surgeon preference; however, if possible, general anesthesia is recommended in the surgeon’s first cases.

The main surgical steps of implantation are:

- Create two 1.0-mm sideport incisions at the 10- and 2-o’clock positions;
- Create the main incision (5.2 or 6.2 mm) at the 12-o’clock position; the incision may be corneal or scleral, but, because it is large, a scleral location is better to avoid inducing astigmatism;
- Fill the anterior chamber with a cohesive OVD;
- Introduce the IOL into the eye and rotate it to the horizontal position;
- Fixate the IOL to the midperiphery of the iris. To perform this step, introduce the blunt needle provided by Ophtec through a sideport incision and forceps through the main incision to hold the optic of the IOL. Then, using a bimanual technique, introduce a sufficient amount of iris tissue through the claw haptics of the IOL. This step is done in each haptic. The amount of tissue grasped by the haptic must be at least 1.00 mm;
- Wash out all of the OVD using I/A or passive irrigation;
- Perform iridectomy or iridotomy; these can alternatively be performed preoperatively with Nd:YAG laser; and
- Suture the wound.

Postoperative medications include subconjunctival dexamethasone and atropine.

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**TABLE 2. OVERVIEW OF PHAKIC IOL SURGERY**

<table>
<thead>
<tr>
<th></th>
<th>AcrySof Cachet</th>
<th>Artisan</th>
<th>Artiflex</th>
<th>ICL</th>
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<td>Miosis</td>
<td>Miosis</td>
<td>Mydriasis</td>
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<td>2</td>
<td>2</td>
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<td>3.2 mm</td>
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<td>Cohesive</td>
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<tr>
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<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Suture</td>
<td>No</td>
<td>Yes</td>
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</table>
methasone plus a topical antibiotic (levofloxacin) and steroid (prednisolone acetate) four times daily for 2 weeks. With careful implantation of the Artisan/Verisyse lens, most complications can be avoided. Because a large incision is used, iris prolapse is sometimes observed, although rarely under general anesthesia. If prolapse is encountered, perforate iridectomy immediately. Some bleeding from the iridectomy may occur, but it is usually resolved with OVD material.

The Artisan is the phakic IOL with the longest user experience, and, therefore, important long-term complications have been published. Complications such as decentration or luxation of the IOL are not due to the lens itself but rather to surgical technical problems, such as poor centration or insufficient tissue grasped by the haptics. Additionally, some reports of endothelial cell loss are invariably associated with shallow anterior chambers. However, if patient selection and surgery are optimal, this IOL should not be associated with significant complications. For a video demonstration of Artisan implantation, visit eyetube.net/?v=pozul.

Artiflex/Veriflex. For Artiflex/Veriflex phakic IOL implantation, miosis can be achieved with topical pilocarpine 2% applied for 15 minutes before surgery or with intraoperative acetylcholine. Topical, peribulbar, or general anesthesia can be used, depending on patient and surgeon choice.

The main surgical steps of implantation are:

- Create two 1.0-mm sideport incisions at the 10- and 2-o’clock positions;
- Create the main incision (3.2 mm in clear cornea) at the 12-o’clock position;
- Fill the anterior chamber with cohesive OVD;
- Introduce the IOL in the spatula provided by Ophtec;
- Introduce the spatula with the IOL into the eye and, once the IOL is in the anterior chamber, press down on and remove the spatula;
- Rotate the Artiflex to the horizontal position;
- Fixate the IOL to the midperipheral iris. To perform this step, introduce the blunt needle provided by Ophtec through a sideport incision and use forceps through the main incision to hold the haptic of the IOL. Then, with a bimanual technique, introduce a sufficient amount of iris tissue through the IOL haptics. This step is done in each haptic, and the amount of tissue grasped by the haptic must be at least 1.0 mm;
- Wash out all of the OVD using I/A or passive irrigation;
- Perform iridectomy or iridotomy; this can alternatively be performed preoperatively with Nd:YAG laser; and
- Close the wound with corneal hydration.

Postoperative medications include subconjunctival dexamethasone plus topical antibiotic (levofloxacin) and steroids (prednisolone acetate) four times daily for 4 weeks.

A carefully performed implantation reduces the risk of complications. Some bleeding from the iridectomy may occur with Artiflex/Veriflex IOL implantation, but it is usually resolved with the OVD. The same long-term complications described for the Artisan lens apply to the Artiflex, but they are mainly related to the surgery and patient selection. In about 5% of eyes implanted with the Artiflex, pigment and giant cell deposits, peaking at 1 month, are seen on the IOL. In the vast majority of cases, these deposits are not clinically significant and disappear by 3 months, and no treatment is needed. If the patient complains of blurred vision, steroid therapy solves the problem. For a video demonstration of Artiflex implantation, visit eyetube.net/?v=hopil.

Visian ICL. For Visian ICL implantation, mydriasis can be achieved with topical phenylephrine 1% and tropicamide 1%. Depending on patient and surgeon preference, topical, peribulbar, or general anesthesia can be used.

The main surgical steps of implantation are:

- Create two 1.0-mm sideport incisions at the 6- and 12-o’clock positions;
- Create the main incision (3.2 mm clear cornea) on the temporal side;
- Fill the anterior chamber with cohesive OVD;
- Introduce the IOL into the cartridge;
- Introduce the cartridge into the eye;
- Inject the IOL slowly into the anterior chamber, watching it unfold in the correct direction (note that the small mark on the leading haptic must be on the right and the mark on the trailing haptic on the left);
- Introduce a soft-tip manipulator through the sideport incisions and press down the tip of the haptics to move the ICL into the posterior chamber; never press on the optic;
- Wash out all OVD using I/A or passive irrigation;
- Constrict the pupil with acetylcholine;
- Perform iridectomy only if central hole is not present (hyperopia); and
- Close the wound with corneal hydration.

Postoperatively, topical antibiotic (levofloxacin) and steroid (prednisolone acetate) should be administered four times daily for 2 weeks. A carefully performed surgery should avoid most complications. Cases of the Visian ICL being implanted upside-down have been described.

TAKE-HOME MESSAGE

- Phakic IOLs can be used to correct high ametropias.
- These IOLs are not associated with wound healing and preserve the natural accommodation of the eye.
- Anterior chamber depth is an important factor for safe implantation of all types of phakic IOLs.
but this is easily avoidable if one pays attention to the position of the haptic marks during unfolding.

The Visian ICL has been associated with different rates of anterior subcapsular cataract formation.\textsuperscript{12} These cataracts are of metabolic nature and are caused by a lack of space (vault) between the ICL and the natural lens. This occurs when the IOL is too short for the eye, as a result of difficulty accurately measuring the sulcus-to-sulcus distance. Other factors such as high myopia and patient age also increase the rate of cataract development. To avoid cataract, if insufficient vault is seen after implantation, the ICL should be exchanged for a longer version.\textsuperscript{9,13}

**TORIC PHAKIC IOLS**

The Artisan, Artiflex, and ICL are also available in toric versions. The implantation of these IOLs is similar to that of the spherical models, except that the axis of the IOL must be placed in the axis of astigmatism. The first step is to mark the axis of implantation in the patient’s eye. This is commonly done at the slit lamp—to avoid cyclo torsion—marking the limbus with a surgical pen. After implantation, the IOL should be aligned along the marked axis. With the Artisan and Artiflex lenses, the axis of the claws must be aligned with the limbus marks. The ICL is always implanted in the same axis (0° to 180°), as the cylinder is included in the lens design.\textsuperscript{14}

**CONCLUSION**

All phakic IOLs have shown outstanding refractive results concerning accuracy and stability.\textsuperscript{7,9} The key to choosing among the available types is the associated complication rate, particularly the long-term complications, as the refractive accuracy is similar across all models.

Phakic IOLs are fundamental tools in a successful refractive surgery practice. If the selection of patients is strict, the surgeon adheres to the described guidelines, and surgery is performed perfectly, phakic IOL implantation should be almost devoid of complications.

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