In the 1950s, José Barraquer, M D; Benedetto Strampelli, M D; M. Dannheim, M D; and D. Peter Choyce, M D, FRCPht, the pioneers of intraocular implants, conducted the first trials using anterior chamber refractive lenses to correct high myopia in phakic eyes. Unfortunately, the initial experiments revealed unacceptable complication rates due to imperfections in IOL design.1 Glaucoma, corneal dystrophy, and hyphema were commonly observed, and anterior chamber implants (particularly refractive phakic implants) acquired a bad reputation.

EARLY PROTOTYPES
It was not until the mid-1980s when Svyatoslav N. Fyodorov, M D; Paul U. Fechner, M D; and I resumed developing phakic implants. Dr. Fyodorov began experimenting with a collar-button, pupil-fixated posterior chamber implant that ultimately led to the development of the Implantable Contact Lens (ICL; STAAR Surgical Company, Monrovia, CA), the Adatomed implant (Chiron Adatomed GmbH, Ratingen, Germany), and the Phakic Refractive Lens (PRL; CIBA Vision, Duluth, GA). Dr. Fechner designed the Worst iris claw implant (OPHTEC BV, Groningen, the Netherlands) and adapted it to correct high myopia. Later, this implant was modified by OPHTEC BV to correct hyperopia and astigmatism.

I imagined an angle-supported implant to correct myopia similar to that designed by Charles Kelman, M D. Over the last decade, the development of phakic implants has been erratic: first one type met with success, then another. In fact, the progress of these lenses was largely hindered by the importance of concurrent investment and research into corneal surgery, microkeratomes, and the excimer laser. Because LASIK developed so rapidly, today, its advantages and limitations are much better known. Due to the procedure’s drawbacks, interest and research in refractive implants are once again gaining momentum.

AVANTAGES OF REFRACTIVE IMPLANTS
Ease of Use
The use of viscous solutions and soft implants has simplified surgery. All anterior segment surgeons are able to perform corneal surgeries without specialized training and with a minimal investment in technology. The accuracy of refractive implants in restoring vision is an acknowledged fact, and, for high ametropia, implantation is generally a better option than LASIK and demonstrates excellent predictability.
Fewer Complications
Apart from progressive myopia and cataract development, the stability of refractive results has been confirmed regardless of the type of implant. Safety and efficacy ratios are superior to those obtained with LASIK, and optical aberrations are fewer. In most instances of high ametropia, the effective optical zone is larger, and the rate of nighttime halos is lower for employing refractive implantation versus corneal surgery. In addition, fewer optical defects occur with industrial lens implantation compared with corneal surgery, because the ultimate shape of the corneal tissue depends on the individual patient's healing ability.

In most cases, refractive implant procedures are reversible. In the event of a sizing or power error, the lenses can be exchanged. In the future, they may even be adaptable, either with light-adjustable technology, as seen in the Light Adjustable Lens (LAL; Calhoun Vision, Inc., Pasadena, CA), or combined with a bioptic.

DISADVANTAGES OF REFRACTIVE IMPLANTS
The disadvantages of refractive implants depend on the lens model and its anatomical situation. Each new modification can induce an unexpected iatrogenous complication.

Angle-Supported Anterior Chamber Implants
Respecting a safety profile has eliminated the endothelial trauma observed with the first models. There must be a minimum of 1.5 mm between the edges of the optic and the endothelium in order to prevent endothelial loss. More than 80% of the first generation (1988 to 1989) of the ZB-type Baikoff phakic IOL implants have been extracted. Since 1990, no known or published corneal dystrophy epidemic has been reported with the new generation of implants. Likewise, the risk of cataract formation, ocular hypertension, or induced uveitis is low. However, there remains the partially unresolved problem concerning the possibility of pupillary ovalization. Most cases have occurred due to an oversized implant, although some clinicians have observed the phenomenon with perfectly sized implants secondary to footplate irritation in the angle.

The future of angle-supported implants lies in perfecting the preoperative evaluation of the anterior chamber's internal diameter. Anterior chamber implants have followed the example of posterior chamber implants and can now be inserted through a 3-mm or smaller self-sealing incision. Today, all of the modern angle-supported implants are developed in this way.

Iris Claw/Iris-Fixated Implants
The main advantage of these lenses is their independence concerning the diameter of the anterior chamber. Only rigid PMMA implants requiring a 5.5- or 6.0-mm incision are CE marked. Pinching the implant at the iris requires a certain amount of expertise, and less skillful surgeons may slightly decenter the implant.

The complication rate of iris-fixated phakic IOLs has fallen. Endothelial cell loss is acceptable, and inflammation, pupillary blocks, and IOL displacements are rare. Few implant dislocations have been observed when the IOL was not firmly fixed at the iris.2,3 Pigment dispersion has been noted in hyperopes,2,3 and, if visual acuity loss is unacceptable, the implant must be removed. To solve the large incision problem, a flexible version of the Artisan lens (OPHTEC BV; marketed in the US as the Verisyse IOL by Advanced Medical Optics, Inc., Santa Ana, CA), called the Artiflex implant, is being developed by OPHTEC BV.

Posterior Chamber Implants
Apart from an ineffective attempt with large-diameter posterior chamber PMMA implants, all posterior chamber lenses now in use are foldable for insertion through a 3-mm incision. Chiron Adatomed GmbH has completely abandoned the implant it was developing because of the high incidence of induced cataract formation.

Currently, surgeons prefer either the ICL or the PRL. The risk of cataract formation is still a problem, especially regarding the ICL. The rate increases with age and insufficient vaulting of the implant.4 Additionally, cases of unexplained intravitreous dislocations with the PRL have been published recently (oral communication with Dimitri Dementiev, MD, at the ESCRS Winter Meeting, Barcelona, Spain, February 2004). Whether this complication is due to surgical trauma, the cutting effect of the PRL’s edges, or a fragile zonule is unknown.
This complication has not been described with the ICL, which is sulcus-fixated.

**THE FUTURE OF PHAKIC IMPLANTS**

Phakic implants offer the advantage of correcting all degrees of ametropia. The only concern associated with their use is the manufacturing of the optic. Today, these lenses are indicated for moderate and even low myopia in cases of corneal abnormalities. For example, astigmatism associated with ametropia can be treated with toric lenses such as the ICL and the Artisan lens. The optical results are superior to those obtained with PRK or LASIK. Correct implant orientation is essential at the time of surgery; otherwise, visual acuity will suffer.

More recently, the correction of presbyopia has been suggested using the Vivarte (manufactured by IOLTECH, SA, La Rochelle, France [Figure 1]) or the GBR Presbyopic multifocal (IOLTECH) implants. The advantage of such IOls is their reversibility, because multifocality can induce unpleasant optical side effects such as halos, glare, loss of contrast sensitivity, and diplopia. In that case, it is theoretically easier and more practical to remove these lenses than to correct a similar problem resulting from multifocal LASIK.

Today, phakic IOls represent only a small part of refractive surgery indications. However, because of their optical qualities and their theoretical and practical advantages, as well as the contraindications and limitations of LASIK, I believe that these implants should soon make up approximately 20% to 30% of the refractive surgery market. The key to successfully using angle-supported implants is evaluating the anterior chamber's internal diameter. Although previously, measuring the external white-to-white measurement was imprecise, today, axial imaging techniques that cover the entire diameter of the anterior segment such as the Scheimplug technique, high-frequency ultrasonographs, and an optical coherence tomographer are in development (Figure 2). Their precision has a 50-µm variation. The software of these devices may shortly be capable of simulating the presence of an implant in the anterior segment, thus indicating whether or not the safety guidelines have been respected.

**INDICATIONS FOR REFRACTIVE PHAKIC IMPLANTS IN 2004**

As previously mentioned, the indications for refractive phakic implants are increasing because of the limitations and contraindications of PRK and LASIK. For example, LASIK is contraindicated for patients suffering from dry eyes because of their risk of persistent postoperative discomfort. In these cases, a refractive implant does not interfere with the production of tears. Moreover, IOP measurements are often inaccurate after refractive photoablation. Indeed, measures are often lower by 5 to 7 mm Hg. In my personal indications, I consider glaucoma suspects with borderline IOPs to be good candidates for refractive implants, because postoperative ocular tension measurements are not disturbed and no correction coefficient has to be applied. This indication seems legitimate because ocular hypertension is not induced by refractive implants, except for postoperative transitory steroid hypertonia.

Approximately 18% of refractive surgery candidates have corneal abnormalities that include a cornea thinner than 500 µm, asymmetrical and irregular astigmatism, and forme fruste or true keratoconus. In addition, there is a risk of corneal ectasia in the presence of one of these factors. I observed a few patients who had undergone refractive photoablation on one eye and a clear lens extraction in his other eye. The eye that underwent corneal surgery developed ectasia, whereas abnormalities had hardly evolved in the eye that underwent intraocular surgery. Moreover, failures, insufficiencies, regressions, or overcorrections following RK, PRK, and LASIK are excellent indications for refractive implants.

**CONCLUSION**

Today’s situation with refractive lens implants is far superior to that of 10 years ago. The concept of this procedure has been accepted. A large number of refractive implants have obtained the CE mark, and two models should soon receive FDA approval. It is mandatory to warn the patient, however, that, because the anterior segment will undergo modifications with age, it will not doubt be necessary to remove the implant after a certain number of years—between 10 and 30—in order to avoid complications.

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