Treatment of Presbyopia during Crystalline Lens Surgery – A Review

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Ophthalmic surgeons should treat presbyopia during crystalline lens surgery. Thanks to the quality and advancements in multifocal implant designs effective, high-quality solutions are already available to treat presbyopia in most patients undergoing crystalline lens surgery. Unless the implantation of multifocal IOLs is contraindicated, the treatment solution that may provide spectacle and contact lens free life should be discussed with patients prior to surgery. Patients nowadays know that these solutions exist and they may be taken aback if they are not offered.

Cataract surgery has reached the standards of clear lens surgery and has become a refractive surgical procedure in its own right. Precise biometrics and IOL power calculations, as well as treatment of corneal astigmatism are prerequisites of success and are rapidly becoming the gold standard. Implants for compensating presbyopia are numerous. These implants make it possible to provide solutions truly customised to patients' needs.

However, surgeons must be well familiar with the technical specifications of the implants to optimize the results and meet patient expectations. Living without eyeglasses after crystalline lens surgery is a daily demand, but also a surgical reality. These patients are provided with a higher level service.

Before going into specific technical details of the implants, it is important to discuss the framework of indications and contraindications. For optimal and predictable functional outcome the eye to be implanted for the treatment of presbyopia should not have any retinal diseases or optic nerve damage, the cornea must be free from any injuries and the tear film must be of satisfactory quality. For optimal results, sensory integrity of the retina and optic nerve, as well as the optical structure (cornea) integrity are required.

Obtaining sphero-cylindrical emmetropia can guarantee optimized vision. Biometrics must be precise and the use of multiple formulas for calculating the spherical power is highly recommended. Several multifocal implants are available in toric versions as well, and it is also important to treat small residual astigmatism so that post surgery astigmatism does not exceed 0.50 diopters.

Patient information is also essential. We must always specify the method of presbyopia management and highlight both the improvement in the quality of vision after multifocal IOL implantation, and some associated effects of these implants. It is also important to mention the risk of halos and that this phenomenon is reduced with time. We also must stress that there is a learning and cortical adaptation period, which is often quick but unavoidable. Sufficient lighting is also an important factor. We must help the patient during the month after surgery with answering their questions and checking their adaptation progress.
Overview of IOLs frequently used to treat presbyopia
Multifocal implants can be classified in different categories. Some IOLs combine different features that are a function of pupil diameter:

- **Diffractive and diffractive/refractive bifocal implants:** AT-LISA (Zeiss), ReSTOR +3.00 (Alcon), TECNIS (AMO)
- **Diffractive/refractive with modified asphericity:** Bi-Flex 677MY (Medicontur) Bunny MF (Hanita)
- **Refractive:** Lentis MPlus (Topcon), ReZoom (AMO)
- **Diffractive trifocals implants:** FineVision (Physiol), AT-LISA Tri (Zeiss), Panoptix (Alcon)
- **Implants with increased depth of field:** Symfony (Abbot)

**Diffractive implants** have different concentric zones on their surface and work similarly to Fresnel lenses. The height of the steps defines the distribution of light energy between the different foci, and the step width determines the addition power. Thus it is easy to understand that by varying all of these parameters, the implants will have very different technical characteristics.

**Purely bifocal implants** support distance vision and have a near focus determined by the width of the steps. With these implants, light energy is distributed between distance vision (65%) and the second, near focal point (35 to 50%). Implants with lower near addition provide better intermediate vision at the expense of a real near vision. In this case, there is no light distributed for intermediate vision. This explains that if these implants are effective at the targeted foci, the intermediate vision will certainly be poor. Defocusing of one eye can be a solution but at the cost of weaker distance vision and the gain is limited.

**Latest generation bifocal implants**: Bi-Flex 677 MY (Medicontur) and Bunny MF (Hanita) feature specific technical specificities, including the asphericity of the steps, thus significantly improving the depth of field while still remaining bifocal. They allow patients to adapt more easily to everyday life activities that mostly require intermediate vision (computers, tablets, smartphones, etc). These implants distribute light between only two foci, which limits light loss and will preserve quality vision for both focal distances even in a medium light conditions. Far vision quality is maintained and near vision effectiveness is beyond doubt.

These new refractive implants include optical zones of varying power and allow a certain of depth of field in an effective compromise maintaining near vision. They are a benchmark in presbyopia treatment in crystalline surgery.
Trifocal implants have been developed to provide intermediate vision that first generation bifocal implants had lacked. Their light distribution also supports an additional, intermediate focus. According to the manufacturers, this intermediate focus is either at 80 cm (FineVision, AT-LISA Tri) or 60 cm (Panoptix). The latest generation of these implants limits the light loss of the diffractive system, and light is repartitioned among three focal points. For example, the Panoptix IOL is a trifocalised quadrifocal implant that channels light to the main foci, thus utilizing 88% of light energy.

Implants with increased depth of field are the result of a new concept. They use a network design called “Échelette” combined with chromatic aberration management. These implants provide a distance vision similar in comparison to monofocal implants, as well as optimal intermediate vision and useful near vision at approx. 40-45 cm. (Figure 1)

Thanks to the diffractive échelette system, the implant provides an increased depth of field, resulting in continuously excellent vision, without hiatus between the different focal points. This type of implant provides quality distance vision as well as continuous intermediate vision and near vision compatible with current patient needs. Furthermore, the Symfony IOL (AMO) has chromatic aberration compensation, which results in enhanced outcomes.

Implants and vision quality
Multifocal implants today offer a lot for patients and provide high quality vision.

Defocus curves: The defocus curves of the latest implants show improvement in the intermediate vision range compared to previous generations, explaining why they are demanded by a lot of patients.

Below are the defocus curves of a few implants offering intermediate vision: the typical double hump appearance has now been replaced with curves without a steep drop in the intermediate vision section, or even curves without two distinct humps.
Figure 2: Monocular subjective defocus curves (y-axis: decimal scale: y/10, x-axis: defocus (diopters), n = 273) 
(source: Michaël Assouline)

Figure 3: Defocus curve (source: T. De Castro, P. Bouchut, 2015)

Figure 4: Defocus curve (source: Abbott)

- Example: Bifocal Bi-Flex 677 MF (Medicontur) (Figure 2)
- Example: Trifocal Panoptix (Alcon) (Figure 3)
- Example: Symfony (AMO), defocus curve without double hump (Figure 4)
Comparative study

Dr. Michaël Assouline presented an interesting comparative study of four multifocal implants at ESCRS 2015 in Barcelona. He compared three relatively new implants with highly emphasized qualities of intermediate vision, and an older type of implant for reference. We would like to share his results through the following figures (Figures 5-11). The key points to remember from his study show that the latest generation of multifocal implants fulfil their purpose better in the intermediate range than the older ones.

After LASIK surgery, diffractive implants are more suitable for the patient than refractive ones because they result in less aberration. An implant with low power addition is also preferable. The Nd:YAG rates were reduced in case of the latest generation IOLs.

![Figure 5: Uncorrected monocular visual acuity. Percentage of eyes (%) with an excellent result (n=826) for near and distance vision (both 20/20 at 3m and J1 at 35cm - blue column), for intermediate vision (J4 at 65cm - red column or J5 at 65cm - green column).]

![Figure 6: Subjective eye preference 1 month after surgery for distance (3m, blue), intermediate (65cm, red) and near vision (35cm, green). The two eyes had been implanted with different implants (n = 180).]
Figure 7: Uncorrected monocular distance visual acuity (% of eyes, n= 874).

Figure 8: Uncorrected monocular intermediate visual acuity (% of eyes, n= 320).

Figure 9: Uncorrected monocular intermediate visual acuity (65cm) (cumulative % of eyes, n= 320).
Figure 10: Subjective binocular defocus curves (mix & match) (y-axis: visual acuity (decimal scale: y/10), x-axis: defocus (diopters), n = 116).

Figure 11: Survival analysis of Nd:YAG laser treatment rates due to PCO. (n(ATLisa) = 94, n(Finevision) = 230, n(LentisMplus) = 414, n(Medicontur) = 88).

Complications in this series of 874 eyes consecutive were rare. Apart from some incidents during surgery (note that capsular rupture did not prevent the implantation of a multifocal IOL and resulted a normal functional outcome), no explantation or request for change was indicated and no complementary refractive laser surgery was necessary.

The range of implant types is wide and allows true customization for quality postoperative vision.
Take home message

This compilation illustrates that implants available today can provide patients with a truly spectacle-free life after lens surgery. Precise preoperative assessment is essential to reveal all contraindications. Attaining sphero-cylindrical emmetropia is a critical key to obtaining optimal results. The total postoperative residual astigmatism should not exceed 0.50 to 0.75 diopters.

Thorough understanding of the technical specifications of the implants is necessary and must be confronted with patient expectations and preoperative assessment.

There is a wide range of implants to choose from, making real customisation possible, and improving postoperative vision.

Today, only a few patients are offered the chance to benefit from such a surgery. The more surgeons know about the possibilities and the results, the more confident they will be in their choices and the more comfort they can offer to their patients.

Financial interests:
Dr Michaël Assouline is a consultant for Medicontur.