Artis SYMBIOSE®, principles and results

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❖ Introduction

The OPTICAL results for the SYMBIOSE® Plus and Mid Implants depend upon the combination of different technologies:

- ✓ First of all, the Artis platform, made of hydrophobic, CBK 1.8 raw material manufactured in France by the Cristalens Group (LANNION FRANCE).
- ✓ A monoblock design with 4 very stable haptics with easy rotation clockwise or counterclockwise during operation, especially for aligning preloaded toric implants.
- ✓ A biometrical calculation carried out by an online calculator.
- ✓ An innovative solution patented and never before used by products on the market (EDOF BIFOCALS TRIFOCALS) with a "phase continuous" diffractive optical system that associated two complementary implants, the Plus and the Mid.

Thus, visual results and comfort are greatly improved thanks to fast visual adaptation, enhanced by a refractive tolerance similar to pseudo-accommodation over a large intermediary and close range.

❖ The ARTIS SYMBIOSE® Implant

▪ Technical Specifications

Optic Diameter	6.00 mm
Overall Diameter	10.79 mm
Shape	Monoblock with a 360° square edge
Optic Design	Aspherical with negative spherical aberration to partly correct corneal spherical aberration
Material	Hydrophobic CBK 1.8 from Cristalens
Optical System	Diffractive Optic with patented continuous phase
Dioptric Powers	From +10.0D to +35.0D by 0.5D
Cylindrical Powers	+0.75D / +1.50D (+2.25D / +3.00D / +3.75D upon request)
Additions (on the implants)	MID: Superior intermediate vision / PLUS: Superior near vision
Estimated A-Constant (SRK-T)	119.3 Ultrasound biometry 119.7 Interference laser biometry
Injection System	Preloaded system
Recommended Incision Size	2.0 mm

Product made in France awarded the "Label of Excellence by the 2020 European Commission"

▪ Multifocal System Optical Principles

The Artis SYMBIOSE® MID & PLUS disruptive innovation is based on 2 innovative principles:

- Continuous phase
- Contrast complementarity

➢ Continuous Phase

Until now, in order to evaluate the quality of an implant, especially a multifocal, only contrast (amplitude) was taken into account. This is represented with MTF curves depending on the addition, which allow to illustrate how contrast is distributed between far vision and near and/or intermediate vision.

However, by definition, as contrast is always positive, these curves don't reflect the phase inversion

phenomena that occur when a letter becomes unclear at a certain distance (an eye chart that is black on a white background may thus become white on a black background). This notion of phase, still little employed, may be compared to image contour. It takes clearness into consideration.

As such, it is interesting to study phase evolution depending upon the multifocal implant's addition.

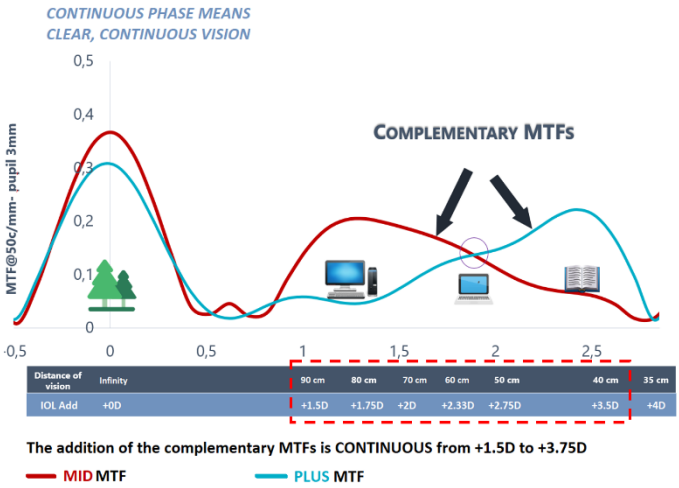
The Artis SYMBIOSE® implants have thus been designed with disruptive diffractive profiles that present no phase inversion over all near vision from additions +1.5D to 3.75D.

Clinically speaking, this means a continuous clear image from 40 to 90 cm.

➢ Complementarity

The Artis SYMBIOSE® implants' second innovation is based on complementary contrast distribution with binocular vision.

The SYMBIOSE® MID is optimized to favor higher contrast in intermediate vision which decreases gradually until near vision (red curve). Inversely, the SYMBIOSE® PLUS has been designed to favor near vision with contrast that increases gradually from intermediate to near vision (blue curve).



The MID and PLUS asymmetrical contrast distribution curves (MTF) complete each other and cross paths around 60 cm.

Thus, combined use of an Artis SYMBIOSE® MID in one eye and an Artis SYBMIOSE PLUS in the other aims to grant sight that is both continuous and clear (thanks to the phase) and contrasted (thanks to the complementarity of the MID and the PLUS) through near vision from 40 to 90 cm.

Optimized contrast with the pair of implants allows to advantageously maintain a very high level of contrast in far vision which is likewise reinforced by apodization in night vision.

Recap

- The Artis SYMBIOSE® Mid and Artis SYMBIOSE® PLUS are both designed to function in association with a continuous phase to allow for continuous, clear sight from 40 to 90 cm in addition to distance vision.
- The MID's contrast with that of the PLUS have been distributed in a complementary way to form a pair of implants allowing optimized contrast in binocular vision and preserving distance vision.

▪ Results

Study led on 10 patients implants bilaterally PLUS and MID non-toric version (intern thesis by Mr. Valentin Pasco). The study of Artis SYMBIOSE® toric version based on the Artis Toric monofocal is still awaiting final results following delays imposed by the COVID 19 pandemic.

Analysis method:

Two examination methods have been used to test the Artis SYMBIOSE® implants:

- Classic LogMAR visual acuity scales, as well as resulting defocalization curves,
- SALZURG READING DESK (SRD) allowing to simultaneously measure all sight parameters between 35 and 90 cm.

In this prospective study, 10 patients presenting a bilateral cataract have been implanted with an Artis SYMBIOSE® MID in one eye and an Artis SYMBIOSE® PLUS in the other eye.

➢ Pre- and Post-operative Exam:

Patients benefited from a complete ophthalmological exam including objective refractive measurement under cycloplegia, subjective visual acuity, air tonometry, slit-lamp exam and funduscopic examination. The biometrical parameters were measured using an optic biometer.

Follow-up visits were planned at D1, D7, M1, M6 and M12. The 12-month post-operative exam included mono and binocular visual acuity with and without correction, for near vision (40cm), intermediate (70cm) and distance (4m). Visual acuity was measured using a Snellen scale for distance vision and SRD for near and intermediate vision. This device was validated as a reliable measuring device for visual acuity during previous studies (5-6-7). Il allows to measure reading speed while having the patient read short, random sentences while varying font size, reading distance, contrast, and screen luminosity. Visual acuity is then calculated in LogMAR units by the SRD according to reading distance. A visual acuity line is only validated for reading speed over 60 words per minute. Luminosity was set to 100 cd and contrast to 100% and 30%.

Defocalization curves were also carried out at a distance of 4m, between +1D and -4D, in mono and binocular vision with correction. Contrast vision was measured using a CSV 1000-E (Vector) in binocular vision, with and without correction. Finally, a quality of life questionnaire was completed by the patient in order to know the perceived quality of vision and patient independence regarding glasses.

▪ Surgical Procedure

Implant calculation aimed emmetropia for both eyes. The A-Constant used was 119.7 and the formula was, respectively, Hoffer-Q for axial lengths (AL) below 22.50 mm, and SRK-T for AL above 22.50mm. The operations (TR-JLB) were carried out 15 days apart for each eye.

Bimanual intervention with a topical anesthesia (oxybuprocaine chlorydrate), with 1.8mm incisions. The implant was intracapsular and sealing was carried out with hydrosuture. Post-operative treatment included corticoids 3 times per day and anti-inflammatory drugs 3 times per day, for 1 month.

BETTER EVALUATE MF FUNCTIONAL RESULTS THANKS TO THE SRD

Two necessities:

Precisely measure sight quality, which allows to compare performance of different implant models,

Evaluate functional results in conditions to those similar to “real life”.

Indeed, in everyday life conditions concerning contrast, luminosity, reading distance for a text, announcement, product price, vary constantly. Typical measurements in a clinic cannot simulate all these variations nor all their consequences for the patient.

By varying parameters in a thorough functional exam, the Salzburg Reading Desk (SRD) allows to both measure variations in performance between different implants and to better simulate different reading conditions. It consists of two screens for reading and follow-up.

On the reading screen random texts appear in order to avoid memorization. Contrast and luminosity may also be modified.

On the follow-up screen reading distance is constantly saved and the patient’s voice is recorded and analyzed in terms of words per minute and reading ease and quality. The text read stays the same size when the patient moves away from the screen: the corresponding gain in visual acuity automatically shows up.

The sentence shown on the reading screen also appears on the follow-up screen, allowing for the person in charge of the exam to check that the recording corresponds to the text suggested to the patient. The words that may be missing or incorrectly read are noted as such.

▪ Results

At the 12-month post-operative appointment, binocular visual results without correction were respectively for far, intermediate and near sight from 0.06 ± 0.09 (-0.1 to 0.16), 0.15 ± 0.1 (0 to 0.32) and 0.2 ± 0.15 (0 to 0.3) LogMAR. Uncorrected visual acuity is better near with the Artis PLUS (p= 0.0423), but we find no difference between the two implants in intermediate vision (p=0.2931). The defocalization curves clearly show a binocular additioning effect.

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In the quality of life questionnaire, 9 patients out of 10 highlighted fast adaptation for activities with near and intermediate vision after a learning period with no difficulties.

Table 1 summarizes average post-operative monocular visual acuity with and without correction.
There is no remarkable difference between the MID and the PLUS, with or without correction, in distance vision as in intermediate vision.

1-Post-operative monocular visual results with and without correction

	SYMBIOSE® MID (LogMAR)	*SYMBIOSE*® PLUS (LogMAR)	p
AVL SC (4m)	0.11 ± 0.11 (-0.1 to 0.22)	0.13 ± 0.08 (0 to 0.2)	0.4003
AVL AC (4m)	0.04 ± 0.1 (-0.1 to 0.2)	0.05 ± 0.08 (0 to 0.2)	0.5236
AVI SC (70 cm)	0.21 ± 0.1 (0 to 0.32)	0.23 ± 0.14 (0 to 0.41)	0.2931
AVI AC (70 cm)	0.2 ± 0.15 (0 to 0.5)	0.23 ± 0.14 (0 to 0.5)	0.4412
AVP SC (40 cm)	0.27 ± 0.17 (0 to 0.5)	0.2 ± 0.13 (0.08 to 0.5)	**0.0423**
AVP AC (40 cm)	0.26 ± 0 .13 (0.08 to 0.4)	0.18 ± 0.14 (0 to 0.5)	**0.0423**

AVL: distance visual acuity. AVI: intermediate visual acuity.
AVP: near visual acuity.
SC: without correction. AC: with correction
Non-parametric Wilcoxon signed-rank test
Values presented: average ± typical variation (range)
Significative statistical difference: p ≤ 0.05.

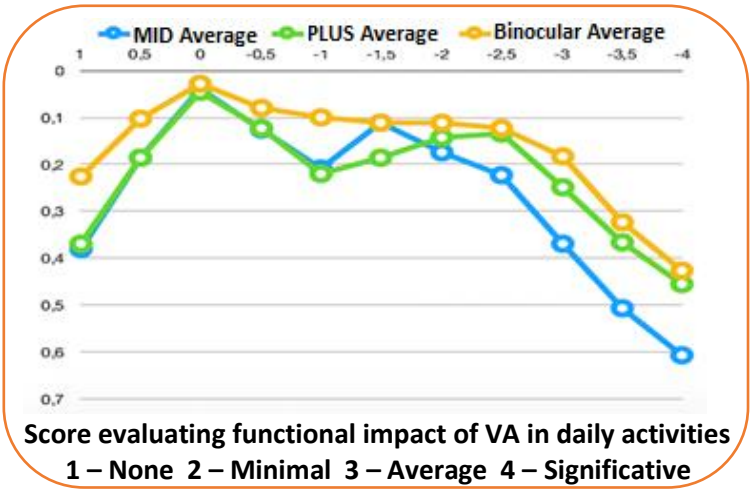
Table 2 summarizes binocular visual results with and without correction. Without correction. Average visual acuity is 0.06 LogMAR for distance vision, 0.15 LogMAR for intermediate vision and 0.2 LogMAR for near vision. In other words, respectively 0.9, 0.7 and 0.6 in decimal visual acuity (0.6 tenths in near vision = P 2-3)
This clearly shows a significative difference in far sight with optical correction : acuity is measured at -0.004 LogMAR (P = 0.0355).

2-Post-operative binocular visual results with and without correction

	Without correction (LogMAR)	With correction (LogMAR)	p
AVL	0.06 ± 0.09 (-0.1 à 0.16)	-0.004 ± 0.01 (-0.1 à 0.16)	**0.0355**
AVI	0.15 ± 0.1 (0 à 0.32)	0.17 ± 0.1 (0.08 à 0.4)	0.5213
AVP	0.2 ± 0.15 (0 à 0.3)	0.16 ± 0.17 (0 à 0.5)	0.1775

AVL: distance visual acuity. AVI: intermediate visual acuity.
AVP: near visual acuity.
Non-parametric Wilcoxon signed-rank test
Values presented: average ± typical variation (range)
Significative statistical difference: p ≤ 0.05.

The defocalization curves clearly show a slight superiority for the MID implant for intermediate vision around -1.50 D and clear superiority for the PLUS implant in near vision. The binocular curve shows an addition on the visual plane with a flattening of the defocalization curve: there is continuous visual quality from intermediate to near vision (from -1 to -2.5D) with visual acuity between 0.1 and 0.12 LogMAR.
The second study in process uses the Artis Toric platform. It includes only 5 patients of the 40 planned and remains thus incomplete that this time. This study confirms the results in Valentin Pasco's thesis, but astigmatism correction, after calculation and placement using VERION and the online calculator give VA and SRD results clearly improved due to refractive precision.



Score evaluating functional impact of VA in daily activities
1 – None 2 – Minimal 3 – Average 4 – Significative

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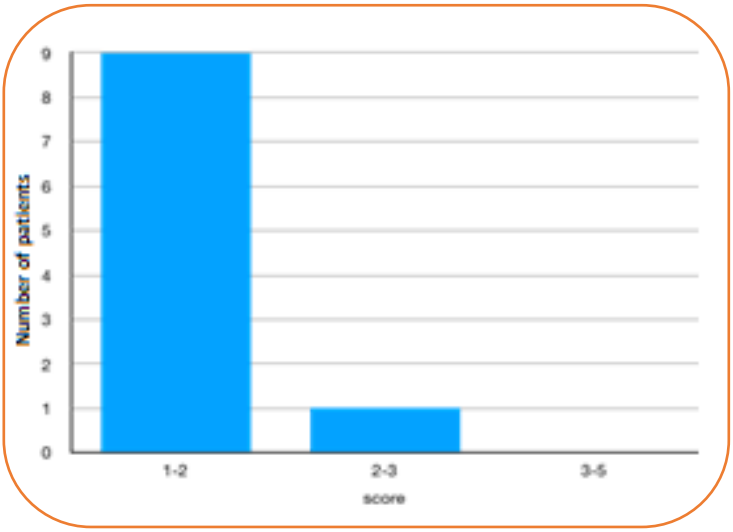

Artis SYMBIOSE® Key Factors

- Artis Implant platform proven since 2010
- Aspherical implant design and acrylic toric hydrophobe with 4 haptics allowing for atraumatic rotation in the capsular bag
- Large refractive field from 10.0D to 35.0D by 0.5D
- Toricity from +0.75D to +3/75D with an online calculator
- Preloaded implant with an incision size of <2mm
- Diffractive multifocality with continuous phase
- Complementary MID and PLUS implants
- PLUS profile implant done first (Wow effect)
- Dominant eye not necessary, but the results remain tied to true binocularity
- 15 days to 1 month between the two eyes, but unilateral implantation is possible by choosing the SYMBIOSE® PLUS first and foremost
- Important to precisely correct the astigmatism
- Refractive tolerance tied to amplitude from pseudo-accommodation
- Quality of use close to real life

❖ Discussion

The SYMBIOSE® first results promise true visual restoration with high level of patient satisfaction.

Ease of adaptation is practically immediate after the first eye. We were surprised, following lock down closure, by patient requests to do the second eye as quickly as possible, even if their satisfaction after operating just one eye is already high; this confirmed the need to operate the first eye with a PLUS to be sure to systematically obtain optimal results on VP (avoid doubts about intermediate VA that is more difficult to exploit from the get go).

Quality of continuous sight ensures that the patient has a large field of depth for clear vision: this continuous reading field with high quality is very different and much easier for patients in daily life than the notion of a “preferential distance, intermediate and near” with EDOF and Trifocals (6-7).

Refractive tolerance gives “flexibility in results”, erasing small refractive errors post-calculations and improving the learning curve.

Undesirable effects, halos, reported by patients (4/10) were moderate and not long-lasting, and typical results of this kind of implant.

❖ CONCLUSION

Although our study, with a higher number of patients and a longer follow-up period, is still in process (especially for toric implants), it is already possible to determine some fundamental notions for patient satisfaction.

Reliable VL, VI and VP visual acuity measurements comparable to SRD results show the binocular synergy created by the MID and PLUS profiles. The continuity of sight provided by the SYMBIOSE® implants is not only high-performance and comfortable, but also tolerant for visual restoration as close as possible to “Real Life”.

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