Artigo de Revisão

Improving Outcomes with Multifocal Intraocular Lenses

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BACKGROUND

With increasing life expectation, cataract surgery became one of the most frequent surgeries in developed countries. With the growing numbers and improving results came increased patient expectations. The introduction in the 80s of multifocal intraocular lenses (MIOL) offered the possibility of spectacle independence after cataract surgery or refractive lens exchange. Although the results with these intraocular lenses (IOLs) improved dramatically over the last decades, some of the problems inherent to the design of the lenses remain, namely reduced contrast sensitivity, especially in mesopic conditions and unwanted photic phenomena.

The preoperative evaluation of these patients is essential in screening retinal and optical nerve pathologies that may imply limitations on postoperative satisfaction.

Also, we cannot neglect the postoperative follow up of these patients, so it is vitally important to know the effects of optical diffractive multifocal lens on the interpretation of the results of evaluation by optical coherence tomography (OCT) and automated perimetry.

IMPROVING OUTCOMES WITH PREOPERATIVE OCT

OCT produces real-time, non-contact, high resolution, cross-sectional images of the retina, enabling the identification of the alterations in its morphology.[1,2] OCT imaging may also be used to quantitatively measure structures such as retinal thickness or retinal nerve fiber layer thickness.[1] Cataract influences both OCT image quality and retinal thickness measurements. However, even in the presence of cataract, OCT scans of individual patients remain reliable for clinical interpretation of gross retinal pathology (defined as signal strength ≥ 6/10), meaning that a foveal contour is often discernable, whereas detail on intraretinal structures might be lost.[3,4] Furthermore, OCT has been shown more effective than indirect ophthalmoscopy or stereoscopic fundus photography in detecting maculopathy (such as idiopathic epiretinal membrane, age-related macular degeneration and ischemic atrophy) in the preoperative examination of patients undergoing cataract surgery. Klein et al. studied 149 patients scheduled for cataract surgery and implantation of a MIOL or toric IOL whose clinical history and examination had excluded macular pathology. In this group spectral-domain OCT identified macular abnormalities in 13,2% of scans.[5] Similarly, In our experience, OCT is sometimes responsible for excluding some candidates to MIOLs, as illustrated in Figure 1.

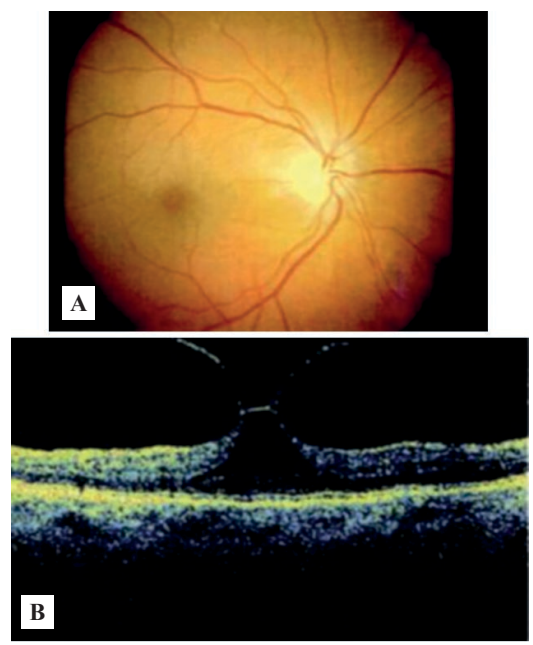

Fig. 1 | 56 year-old woman being evaluated for cataract surgery whose fundoscopy and retinography (a) showed no remarkable findings. The macular OCT (b), however, revealed vitreomacular traction with loss of the normal foveal contour – a possible contraindication for MIOL implantation.

For reasons stated above, OCT has become a fundamental evaluation tool in candidates for MIOL implantation, safeguarding the patient's and surgeon's interests. In short term follow-up studies, photic phenomena are the main cause of MIOL explantation.[6] It is likely that, if studies with longer follow-up were conducted, retinal pathology might become an important cause of MIOL explantation and patient dissatisfaction, once again overstressing the role of OCT in this context. And, we must also consider that, as OCT rapidly becomes the standard in the evaluation and identification of vitreoretinal pathology, the application of this instrument to eyes with a MIOL will increase as patients age and the risk of vitreoretinal disorders, namely macular degeneration and preretinal membranes, also increases.

OPTICAL COHERENCE TOMOGRAPHY AFTER MIOL IMPLANTATION

Multifocal intraocular lenses have been associated with quality of vision issues, particularly in low lightning conditions. But it is less well known the effect these IOLs can have on retinal imaging and measurements from devices such as OCT. There is a report of reduced OCT signal strength with refractive multifocal contact lenses.[7] A previous study (Inoue et al.) described wavy artifacts in the image on the line-scanning ophthalmoscope of the spectral domain-OCT (Cirrus 4000 HD-OCT) in patients with diffractive MIOLs. However, despite these artifacts seen on OCT line-scanning ophthalmoscopic images, the OCT and fundoscopic images in eyes with a MIOL were comparable to those in eyes with a monofocal IOL.[8]

There are also two other studies[9,10] which evaluated the impact of MIOLs on the accuracy of retinal OCT measurements through comparison with a control group with monofocal IOL. Skiadaresi et al. evaluated OCT measurements following implantation of LENTIS Mplus (Oculentis GmbH, Berlin, Germany), a refractive MIOL. They used Topcon 3D OCT-1000 (Topcon, Oakland, USA) and found neither image artifacts nor alteration in macular thickness or volume measurements.[10] Dias-Santos et al. accessed the accuracy of retinal OCT in patients with a diffractive MIOL: Acrysof ReSTOR SA60D3 (Alcon Laboratories, Fort Worth, USA) or Tecnis ZM900 (Abbott Medical Optics) using OCT Heidelberg Spectralis (Heidelberg Engineering, Heidelberg, Germany). They found a statistically significant decrease in the OCT image quality in the diffractive IOL group, but the measurements in the macular area were not affected by the optical design of diffractive IOLs.[9]

Our group also studied 30 eyes of 16 patients implanted with MIOL: TECNIS Symfony (17 eyes) or trifocal Finevision (13 eyes), which were compared with a control group with 12 eyes of 8 patients who underwent uneventful phacoemulsification with implantation of a monofocal IOL: TECNIS 1-Piece Aspheric IOL (Abbott Medical Optics) or Acrysof Aspheric IOL (Alcon Laboratories). The demographic data of the patients is presented in Table 1.

We included only eyes without significant ocular comorbidities (namely posterior capsule opacification, glaucoma, corneal or vitreoretinal pathology). The Cirrus-HD OCT 4000 was used to perform macular imaging at least 1 month postoperatively in all eyes. Acquisition was made with the macular cube 512x128 scan. This mode acquires scans at a length of 6.0x6.0 mm and with a resolution of 128 lines of 512 A-scans per line, with the fixation on the macula. Central thickness and macular volume were recorded. We also calculated the mean thickness in the 3 mm and 6 mm concentric circles of the automatic map (average of the all the quadrants in each circle). The signal strength was obtained for all eyes. Statistical comparisons between groups for macular thickness, macular volume and OCT signal strength were assessed with Mann-Whitney U test, with a p-value of 0.05 being considered as statistically significant. Our results are summarized in Table 2.

There were no statistically significant differences in any measured or calculated values for macular thickness and

Table 1 | Patient demographic data and implanted IOL model.

	Multifocal IOL group	Monofocal IOL group
Sex (M/F)	4/12	2/6
Age (Y)	63 (range 50-80)	71 (range 58-84)
Spherical equivalent (mean ± SD) (D)	0,88 ± 2,59	0,86 ± 2,88
IOL model	17 TECNIS Symfony 13 Physiol Finevision Trifocal	4 TECNIS 1-piece Aspheric 8 Alcon Acrysof Aspheric (SN60WF)

Table 2 | Medians of central macular thickness, mean macular thickness in 3 mm and 6 mm circles, macular volume, OCT signal strength and statistical significance between the two IOL groups.

	Multifocal IOL group	Monofocal IOL group	*P*-value
Central macular thickness (µm) Median (Min, Max); IQR	269.50 (221.00,298.00); 23.25	264.00 (222.00-283.00); 14.00	0.263
Mean Macular thickness 3 mm circle (µm) Median (Min, Max); IQR	330.13 (286.75, 348.50); 31.13	318.13 (286.25,344.75);24.44	0.146
Mean Macular thickness 6 mm circle (µm) Median (Min, Max); IQR	282.50 (253.00,309.50); 27.94	275.75 (246.00,297.25); 22.56	0.263
Macular volume (mm^3) Median (Min, Max); IQR	10.40 (9.20-11.10);1.03	10.00 (9.10,10.90);0.80	0.240
OCT signal strength Median (Min, Max); IQR	9.00 (6.00,10.00); 1.00	9.50 (9.00,10.00);1.00	0.002

macular volume between the two groups. However, median OCT signal strength was significantly higher (p=0,002) in the monofocal IOL group (9,50) compared with the MIOL group (9,00), indicating a better image quality in this group. Nevertheless, in the MIOL group mean signal strength was still over 6 – the minimum quality score recommended by the manufacturer. However, our results should be interpreted with caution since our monofocal IOL group had a small number of patients and we evaluated different models of IOL in each group.

In conclusion, the optical design of MIOLs may affect OCT imaging, however the available data show that it does not seem to compromise the role of this important tool in the diagnosis and follow-up of vitreoretinal disorders.

MIOLS IN GLAUCOMA PATIENTS. IS IT POSSIBLE?

When approaching a patient with cataract and glaucoma who desires spectacle independence, the severity of the disease must be considered. As discussed above, with any premium surgery, an evaluation of the retina and optic nerve with OCT is increasingly more common, being a valuable tool not only to quantify glaucomatous damage but also to detect macular disease and predict outcomes. Preexisting visual field defects that might influence the function of a MIOL should also be considered.

Some of the new technologies included in premium IOLs are of particular importance in glaucomatous patients. Considering that pupilar response in glaucoma patients can be altered, and as we know that pupil size can influence some types of premium IOLs performances, it is advisable to choose a premium IOL model independent of pupil's size (ie. diffractive versus refractive multifocal IOLs). Aspheric IOLs compensate for the positive spherical aberration of the cornea and have been shown to improve mesopic and scotopic contrast sensibility after cataract surgery, as well as to decrease the incidence of unwanted photic phenomena. It has been demonstrated that glaucoma reduces contrast sensitivity independent of visual acuity. This reduction affects primarily mesopic levels and is correlated not only with visual field loss but also quality of life. As glaucoma decreases contrast sensitivity, the choice of aspheric IOLs may be even more important in these patients. In addition, this technology may be combined with toricity to correct preexisting astigmatism which might reduce visual function after cataract surgery with a MIOL. Since corneal astigmatism induction is greater with trabeculectomy than with other glaucoma surgeries, care must be taken with using toric IOLs when combining trabeculectomy with cataract surgery.[11,12]

A newer IOL technology is the TECNIS Symfony extended depth of focus IOL. This IOL not only corrects spherical but also chromatic aberration of the eye, resulting in an increased depth of focus which, as claimed by the manufacturer, improves intermediate vision and results in higher spectacle independence with less photic phenomena. Furthermore, the study of the visual performance of this IOL shows a superior contrast sensitivity function

in comparison with other MIOLs.[13] Given these specific characteristics and outcomes, this IOL may be an option in patients with early to moderate glaucoma desiring some level of spectacle independence.

In summary, although concomitant cataract and glaucoma may represent, nowadays, a relative contraindication for implanting premium IOLs, a careful patient evaluation and selection can reveal potential candidates for MIOL implantation. For patients with ocular hypertension, glaucoma suspects and early stable glaucoma, any of the premium IOLs (multifocal, extended depth of focus) can be an option. In moderate or severe glaucoma, the surgeon must consider several factors, including preexisting visual deficits, characteristics of the IOL to be implanted and the effect of surgery in the future evaluation and follow-up of glaucoma. In the particular case of glaucoma patients with pseudoexfoliation it is debatable, even those with stable disease, given the risk of intraoperative complications and late postoperative IOL decentration when there is zonular weakness. So should be excluded progressing patients and those with severe glaucoma or pseudoexfoliative glaucoma.[14]

Functional and structural evaluation of glaucoma patient should be repeated soon after the eye has recovered following cataract surgery, because, as already mentioned, all the investigations can be compromised by crystalline opacification, and a new baseline can be established.

Cataract surgery can improve the quality of vision in patients with glaucoma, although lost contrast sensitivity and visual field defects remain unchanged. Unfortunately, there is little published data of the outcomes of cataract surgery with MIOLs in patients with glaucoma, most of the evidence being from anecdotal experience. One article reported outcomes of cataract surgery with MIOLs including patients with glaucoma and found similar outcomes to monofocal IOLs, except for improved near visual acuity.15 For these reasons, the use of a MIOL in these patients must be approached with caution, through a careful informed consent process reviewing the benefits and drawbacks of this kind of lenses, especially as the severity of glaucoma increases.

POSTOPERATIVE AUTOMATED PERIMETRY WITH MIOL

Glaucoma is an insidious chronic eye disease that results in retinal sensitivity loss. This loss may be evaluated through automated perimetry, which is a fundamental tool for glaucoma diagnosis and follow-up. Since both glaucoma and MIOLs may reduce contrast sensitivity, it is possible to theorize that MIOLs may affect proper glaucoma assessment.

Cataract also decreases the sensitivity of diagnostic tests that document glaucoma progression. There have been many studies regarding cataract extraction impact on visual field in glaucoma patients, but none of them was centered on MIOLs. Those studies have demonstrated that visual field parameters, namely mean deviation (MD) and pattern standard deviation (PSD) changed after cataract extraction. MD was shown to improve after cataract surgery in the majority of studies. Concerning PSD values, the data are not so consistent; some studies have shown no change in PSD postoperatively, while others have demonstrated deterioration of PSD.[16]

Patients with diffractive MIOL have clinically relevant reduction of the visual sensitivity as assessed with standard automated perimetry size III and size V. The reduction seems to be related to the multifocal design of the IOL rather than to pseudophakia.[17] This reduction interferes with the assessment of common eye diseases such as glaucoma.

Farid et al. regarded the effect of MIOL on nonspecific reduction of MD upon Humphrey standard achromatic perimetry (SAP) 10-2 testing with Swedish Interactive Threshold Algorithm (SITA) standard thresholds.[18]

A subtle contrast sensitivity (CS) change might already alter central 10-2 visual field performance. Pierre et al. noted that the luminance contrast values of patients with yellow-tinted IOLs were significantly lower than those of patients with clear IOLs, in a series of 25 patients.[19] And Vingolo EM et al. compared the visual acuity and CS in eyes with the Acrysof ReSTOR multifocal intraocular lens and eyes with the monofocal Acrysof SA60AT IOL. The MIOL provided lower contrast sensitivity than monofocal IOL.[20]

There is stronger evidence of reduced retinal sensitivity in subjects with MIOLs compared to subjects with monofocal IOLs, however most of the studies were performed in healthy subjects, not in patients with glaucoma.

We studied a small group of healthy eyes with MIOL implantation (n=22), 10 eyes had TECNIS Symfony and 12 eyes had trifocal Finevision IOL. The results, in terms of MD and PSD, are shown in Table 3.

We found a mean MD of -2,4 dB, being lower for the Finevision Group (-2,63 dB) when compared to the Symfony group (-2,11 dB). This difference was not statistically significant (p>0,05). We had a small monofocal IOL implanted group, with 5 eyes. As the literature reports, our MD value for monofocal IOLs was higher than the mean MD for multifocal. Even though Symfony eyes had higher MD than monofocal eyes. The small number of eyes included does not allow definite conclusions.

Table 3 | Standard Automated Perimetry results: Mean Deviation (MD) and Pattern Standard Deviation (PSD) values for each IOL group

	MD (dB)	PSD (dB)
Multifocal IOL Group (n=22)	-2,40	1,84
Finevision IOL (n=12)	-2,63	1,90
Symfony IOL (n=10)	-2,11	1,80
Monofocal IOL Group (n=5)	-2,26	2,3

CONCLUSIONS

A comprehensive preoperative assessment is mandatory when considering the implantation of a MIOL. OCT has become an essential tool in this task, allowing a thorough macular analysis and identifying potential vitreomacular abnormalities that may compromise the surgical outcome. It should be part of the evaluation of every candidate to a MIOL.

The implantation of premium IOLs in patients with cataract and concurrent glaucoma is still controversial. The progressing nature of the disease, the defects in visual function that can be induced and the presence of anatomic characteristics that can compromise the surgical outcome complicate the decision of using premium IOLs in glaucoma patients. There are, however a subgroup of glaucoma patients in which the use of these IOLs can be considered: ocular hypertension, glaucoma suspects and early stable glaucoma.

The influence this IOL technology can have on postoperative follow-up and evaluation of our patients is still uncertain. Although for OCT imaging the available data suggest some compromise of image quality, the retinal measurements made do not seem to be affected by the diffractive optics of the IOLs. For automated perimetry, the limited published data trends towards a reduced retinal sensitivity in SAP that seems related to the multifocal design of the IOLs. The lack of large randomized trials of premium IOLs use in patients with glaucoma does not allow to establish the impact these IOLs design can have on glaucoma diagnosis or progression assessment. Nevertheless, it is probably advisable to set a new perimetric baseline in patients with MIOLs with (suspect) glaucoma and preferably in all patients with MIOLs to guarantee a correct interpretation of any future abnormality.

Our goal should be to meet our patient's expectations, without adversely influencing future disease diagnosis, monitoring and possible treatments.

With these considerations in mind, we will be able to take better advantage of this technology and the increased number of patients it brings to our practices for many years to come. Further studies are, however, necessary to achieve better outcomes.

Keypoints

- OCT identified macular abnormalities in 13,2% in patients scheduled for cataract surgery and implantation of a MIOL whose clinical history and examination had excluded macular pathology.
- Optical design of MIOLs may affect OCT imaging, however the available data show that it does not seem to compromise the role of this important tool in the diagnosis and follow-up of vitreoretinal disorders.
- Although concomitant cataract and glaucoma may represent, nowadays, a relative contraindication for implanting premium IOLs, a careful patient evaluation and selection can reveal potential candidates for MIOL implantation.
- It is probably advisable to set a new perimetric baseline in patients with MIOLs with (suspect) glaucoma and preferably in all patients with MIOLs to guarantee a correct interpretation of any future abnormality.
- The limited published data trends towards a reduced retinal sensitivity in standard achromatic perimetry that seems related to the multifocal design of the IOLs.

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