INTRODUCTION

The recent addition of intraocular lenses to try to achieve a satisfying vision at a range of distances is a major advance in cataract surgery. To achieve a vision as similar as possible to before presbyopia has become the objective of cataract surgery, popularising multifocal intraocular lens implantation in the last few years. This hypothetical benefit is not alien to glaucoma patients who need cataract surgery. Multifocal intraocular lenses provide an independence from glasses to a high percentage of patients; however, after implantation, it is not uncommon to experience different undesired optical effects such as halos, glare and a decrease in contrast sensitivity. These dysphotopsic effects do not prevent these lenses from providing a high level of satisfaction to most of our patients.

As for the issue at hand, it is impossible to avoid the anatomical characteristics and the morphological and functional changes in pathological conditions that may occur in the setting of glaucoma and which, sometimes, may give way to unsatisfying results.

In this chapter we take into consideration the potential benefits, disadvantages and problems that may stem from the use of multifocal lenses in patients with glaucoma. To understand the potential interaction between the functional defects caused by glaucoma and the potential undesired optical effects induced by multifocal lenses, we must review all of them in detail. Once these points have been revised, we will be in a position to consider which would be the potential indications for these lenses in glaucoma patients and which would be the most appropriate type of implant.

ABSTRACT: To achieve a vision as similar as possible to before presbyopia has become the objective of cataract surgery, popularising multifocal intraocular lens implantation in the last few years. This hypothetical benefit is not alien to glaucoma patients who need cataract surgery. Multifocal intraocular lenses provide an independence from glasses to a high percentage of patients; however, after implantation, it is not uncommon to experience different undesired optical effects such as halos, glare and a decrease in contrast sensitivity. These dysphotopsic effects do not prevent these lenses from providing a high level of satisfaction to most of our patients.

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the potential indications for these lenses in glaucoma patients and which would be the most appropriate type of implant (Section 3).

FUNCTIONAL AND STRUCTURAL CHANGES IN PATIENTS WITH GLAUCOMA

Patients with cataracts and glaucoma aren’t only patients with cataracts and morpho-functional changes in the optic nerve and visual field. They also show anatomic, structural and functional differences that may affect the preoperative assessment (visual acuity, visual field, and contrast sensitivity), surgical intervention (anterior chamber depth, angle, dilation of the pupil, and zonular instability) and postoperative follow-up (ocular hypertension and associated risks) in cataract surgery. All of these aspects should determine either per se or due to its potential risk of development, our choosing and indication criteria for implanting one intraocular lens or another, more so if it is a multifocal implant.

Functional changes: Visual acuity and contrast sensitivity in patients with glaucoma

Visual acuity is a poor indicator of functional assessment in glaucoma. Even patients with advanced glaucoma can show excellent visual acuity; if these same patients receive a visual field assessment or contrast sensitivity tests the degree of disease progression becomes much more obvious. In patients with cataracts and glaucoma, cataracts can jeopardise visual acuity to a greater extent than glaucoma; in these cases we should assess every available diagnostic test to determine the real progression of cataracts and glaucoma in order to lay the foundation for our surgical indication and to disclose a preoperative visual prognosis.

Contrast sensitivity has proven more sensitive than visual acuity in assessing the ability to perform daily activities. Both cataracts and glaucoma can jeopardise in a similar way contrast sensitivity, but changes due to cataracts can normally be reversed after surgery unlike those induced by glaucoma. In any case, we believe that contrast sensitivity cannot but complement other more specific cataract or glaucoma diagnostic tests.

Since Campbell & Green’s first publication on the deterioration of contrast sensitivity in patients with open-angle glaucoma, this parameter has been thoroughly studied to determine its efficacy as a diagnostic test for glaucoma. Liska found that contrast sensitivity is reduced both in patients with established glaucoma and in patients with suspected glaucoma.

Different techniques have been used to measure contrast sensitivity; some of them have shown a significant difference between glaucomatous and normal eyes, but others showed no difference. Glovin-sky determined that the whole-field scotopic sensitivity distinguishes between normal eyes, eyes with glaucoma or suspected of having glaucoma, thus making it useful in the screening for glaucoma. Mesopic contrast sensitivity has been recently studied in glaucoma. This study showed reduced contrast sensitivity in glaucomatous eyes under photopic and mesopic conditions for all spatial frequencies. Furthermore, the measurement of photopic and mesopic contrast sensitivity was significantly correlated with cup to disc ratio and the photopic contrast sensitivity with spatial frequency of 6 cycles per degree was significantly correlated with the severity of the glaucomatous damage. These results indicate that foveal contrast sensitivity is impaired in glaucoma despite good visual acuity, suggesting that central visual function damage occurs in glaucoma. These results corroborate previous studies while adding psychophysical evidence that foveal function is impaired in glaucoma, supporting previous histopathological, anatomic and psychophysical studies.

Furthermore, changes in contrast sensitivity occur in the early stages of the disease, providing a useful tool for functional vision in glaucoma patients and correlate with loss of visual field in glaucoma patients who still have a good visual acuity. There is evidence showing that the progression of the disease affects more contrast sensitivity vs. visual acuity.

The ability to perform activities of daily living according to the Assessment of Disability Related to Vision (ADREV) in patients with glaucoma correlates with visual acuity and binocular contrast sensitivity. A contrast sensitivity worsening, in the setting of glaucoma, will imply a greater difficulty to perform daily tasks.

Therefore, glaucoma causes, as well as multifocal lenses, a decrease in contrast sensitivity, particularly in mesopic conditions. However, the decrease in contrast sensitivity caused by this type of lenses can be compensated in these patients by an aspheric lens, as will be discussed later on. Structural changes in patients with glaucoma

Glaucoma can present itself in many different ways and there are also many different structural and anatomical changes that can be seen in these different clinical presentations of glaucoma. We will discuss those whose we believe to be more common.

Narrow anterior chamber

It is not constant in every form of glaucoma; however, it is common in closed-angle glaucoma. In these cases, cataract surgery will be more difficult. The new diagnostic imaging tests provide enough information to suspect the risk of developing an acute glaucoma or to anticipate potential surgical risks in a particular case.
The exploration should assess the depth of the anterior chamber and the status of the angle of the anterior chamber. The depth of the anterior chamber is easily measured; traditional ultrasound biometers and interferometry optical biometers are useful. Traditionally, the angle of the anterior chamber was assessed through gonioscopy but nowadays there are other methods such as ultrasound biomicroscopy and anterior segment optical coherence tomography, which can provide extremely valuable information; the latter provides unbiased information and with ultrasound biomicroscopy we can «see» retro-iridian structures which may affect the angle.

The depth of the anterior chamber will alert us of a potential technical difficulty for the surgery and the asymmetry between the eyes of said measure can report a potential zonular dialysis, which may otherwise go unnoticed in direct examination with the slit lamp.

**Pupil**

In many occasions, and due to different causes, the pupil of a patient with glaucoma presents a poor dilation. The use of miotics, the presence of synechiae, the morphological changes in the iris seen in some pathologies such as pseudoexfoliation, and the anterior segment dysgenesis seen in some cases, condition miosis. It is necessary to assess before surgery if miosis can be reversed; as is the case when miotics are used and then suspended or in the presence of synechiae if they are surgically removed, or not reversible as is the case with pseudoexfoliation.

A poor dilation not only makes surgery more complicated, it can also condition the functional performance of a multifocal implant. We know there are pupil-dependent multifocal lenses that should not be implanted in cases of small pupils, as its functionality might be compromised in distance vision in some cases and in near vision in others, depending on its design. If the miotic pupil is not reversible, as might be the case in pseudoexfoliation, it should be taken into account when deciding on the potential implantation of a multifocal intraocular lens.

**Zonular weakness**

Some patients with glaucoma, especially those with pseudoexfoliation, can present different levels of zonular instability.

Zonular weakness can be seen preoperatively, making some intraoperative complications more predictable, conditioning our previous selection of intraocular lens; however, it might not be noticeable until the surgery thus changing our initial choice of lens. Furthermore, it is a widely known fact that the optical performance of any intraocular lens is extremely sensible to any kind of decentration; this is especially true for aspherical, toric and multifocal lenses.

Pseudoexfoliation is the eye disease that most commonly presents risk of complications in cataract surgery, some of them due to limited zonular integrity. The situation is complicated by the uncertainty if the long-term behaviour of the capsular sac, with the possibility of a bag-lens subluxation in the future. The degree of severity varies from mild cases without zonular weakness, which behave as normal cases, to cases with frank phacodonesis or lens subluxation before the surgery. However, glaucoma is more common in patients with this syndrome and if present, it is more aggressive, has a greater progression and long-term control becomes more difficult. On the other hand, due to the higher risk of intraoperative complications, there are authors who advocate an early cataract surgery in these cases as the risk of complications increases if the cataract is too developed. If we were to consider an early cataract surgery in pseudoexfoliation, probably a young patient with good vision, the need for a multifocal lens would be more likely. In any case, we believe that in patients with cataracts, glaucoma and pseudoexfoliation considering the implantation of a multifocal lens requires an exhaustive exploration and a likewise exhaustive review of the indication criteria.

We believe that, *a priori*, patients with glaucoma and pseudoexfoliation are not ideal candidates for the implantation of a multifocal lens.

**MULTIFOCAL LENSES**

Intraocular multifocal lenses are, in general, complex lenses and of recent use in surgery. Originally intended for healthy eyes, its wide use has caused patients with certain concurrent pathologies to consider them too. Some issues must be revised.

**Multifocal lenses in patients with no other ocular alterations**

Multiple studies have confirmed the efficacy of multifocal lenses in providing a better near and intermediate visual acuity without correction than monofocal lenses with a similar level of distance visual acuity.

Leyland & Pringle published a review in *Cochrane* confirming these findings. The aim of the review was to assess the effects of multifocal intraocular lenses, including effects on visual acuity, subjective visual satisfaction, spectacle dependence, glare and contrast sensitivity, compared to standard monofocal lenses. In this revision, 8 clinical trials were identified. It was found that multifocal lenses are effective at improving near vision relative to monofocal lenses without effect on distance acuity. Freedom from glasses was achieved more frequently in patients with multifocal lenses.
Even with the first multifocal intraocular lens models, after their implantation, only 20% of the patients needed some kind of glasses and, if needed, the power was lower than the one required after the implantation of a monofocal lens\(^3\). Nowadays, the need for glasses after the implantation of a multifocal lens is even lower\(^40,41\). Nevertheless, these lenses have shown ocular side effects which, some times, give rise to patients’ dissatisfaction\(^1,42\). However, the evolution of the multifocal designs has reduced the incidence of glare and dysphotopic phenomena in comparison to the earlier designs. (Longhena P, Gaiba G, Brandi L, et al. Array MIOL vs. multifocal IOL with new profile and material: ReZoom. Paper presented at the ASCRS Conference; April 2005; Washington DC; Dick HB. Experience with ReZoom IOL: comparing this lens with the array. Cataract Refract Surg Today 2005; 5960: 1-2.)

This confirms the benefits of multifocality and that, generally, it compensates for the inconveniences of the dysphotopic phenomena they might create. This is a true fact for patients without concurrent pathology. It would be necessary to confirm the same arguments and the same benefits in patients with glaucoma; dysphotopic phenomena shouldn’t affect these patients in a different way. If selection criteria are strict for patients without an ocular pathology associated, they should be even stricter for those cases presenting glaucoma.

Multifocal lenses in patients with other ocular alterations

Literature on the impact of multifocal lenses in eyes with ocular comorbidity is scarce; only one study raises this issue. Kameth\(^43\) included in a study patients with diabetic retinopathy, glaucoma, ARMD and optic neuropathy. Out of all the patients with concurrent diseases, 11 were patients with glaucoma and 6 were patients with ocular hypertension who received multifocal implants in comparison to 12 eyes with glaucoma which received a monofocal lens as the control group. No difference was evidenced between both outcomes, except that the multifocal lens group had a better near visual acuity without correction. This study underlined that patients with ocular comorbidity could benefit from the implantation of a multifocal lens; nevertheless, it should be stressed that the sample of the study includes a small number of patients and that refractive optics, today largely in disuse, were studied.

More studies are necessary, including larger samples and assessing diffractive optics.

Multifocal lenses and contrast sensitivity

There are two kinds of visual complaints from patients who have received a multifocal implant\(^37,44\). On the one hand, some patients may suffer a decrease in visual acuity and some decrease in contrast sensitivity and, on the other hand, there are the so-called dysphotopic phenomena that we have been discussing in this chapter. These are the reasons why, generally, multifocal lens implantation is only recommended in healthy eyes\(^54\). It is understood that for patients suffering a disease that compromises contrast sensitivity, the loss of sensitivity inherent to multifocal lenses could aggravate it further.

Multifocal lenses can be classified into refractive, diffractive, hybrid diffractive-refractive and refractive with rotational asymmetrical lenses. Decrease in contrast sensitivity has been described with all of these types of lenses. Patients implanted with the multifocal lens AcrySof ReSTOR versus the monofocal AcrySof SA60AT presented statistically lower monocular photopic contrast sensitivity\(^45,46\). Ravalico (Ravalico G, Bilateral implantation of Tecnis ZM900 or ReSTOR diffractive IOLs versus ReZoom multifocal IOL. Presented at the Annual symposium of the American Society of Cataract and Refractive surgery; June 2006; Washington DC, USA) showed that the hybrid diffractive-refractive AcrySof ReSTOR (Alcon) lens, the refractive ReZoom (Abbott Medical Optics) and the diffractive Tecnis (Abbott Medical Optics) slightly worsened contrast sensitivity.

Steiner\(^47\) carried out a study with 466 patients in which the same effect on contrast sensitivity was demonstrated with this kind of multifocal lenses. More specifically, the multifocal lens AMO Array (Abbott Medical Optics) has been associated with reduced contrast sensitivity at low contrast levels\(^48,49\). The multifocal intraocular lens Oculentis Mplus, with a refractive rotational asymmetrical design, has shown values of photopic distance contrast sensitivity similar to a monofocal lens, but lower photopic values for near vision at high frequencies and lower mesopic values at high and medium frequencies\(^50,51\). Zhao\(^52\) found similar results for AcrySof ReSTOR.

A recent comparison of the visual quality between two diffractive multifocal lenses, AcriLISA and Tecnis, has demonstrated slightly better visual quality variables in the AcriLISA arm, although no statistically significant differences were achieved\(^53\). In another study, comparing contrast sensitivity with AcriLISA and AcrySof ReSTOR SN6AD3, both lenses provided contrast sensitivity within normal ranges under photopic conditions while reducing contrast sensitivity under mesopic conditions, showing no differences between both models\(^54\).

Aspheric multifocal lenses

The cornea has a positive spherical aberration that does not vary significantly with age. This positive spherical aberration of the cornea is compensated, in
a young person’s eye, with the negative spherical aberration of the crystalline (fig. 1). With advancing age, the crystalline suffers a decrease in its negative spherical aberration, which reaches values close to zero at age 40, henceforth it can also become positive. As a result, the total spherical aberration of the eye becomes more positive as the spherical aberration of the crystalline not only does not compensate the positive aberration of the cornea, but also adds to it, reducing contrast sensitivity. Between ages 20 and 70 total aberrations of the eye increase in 300%.

The spherical aberration of the pseudophakic eye with an implantation of a spherical lens is similar to that of healthy eyes of the same age and higher than young eyes that have not undergone surgery. This is because this kind of lenses has a positive spherical aberration that adds to the corneal positive spherical aberration (fig. 2).

The first intraocular aspheric lens, Tecnis, was intended to compensate the positive spherical aberration of the cornea and to achieve an increase in contrast sensitivity. This lens has a prolate anterior surface with an asphericity of about 0.27 µm. This value was based on the outcomes of studies that estimated the average corneal aberation of the general population at +0.27 µm for a 6 mm pupil. Clinical studies comparing Tecnis with other non-aspheric intraocular lenses have found that Tecnis improves contrast sensitivity both under mesopic and photopic conditions. Nevertheless, more recent studies have found that a slight positive aberration (+0.10 µm) is beneficial and is associated with a better visual acuity. This is due to the fact that a spherical aberration of such magnitude increases the depth of focus, allowing a certain amount of multifocality and improving the tolerance of ametropy.

Following these findings, Beiko has found that eyes with a customized selection of total spherical aberration about +0.10 µm had a better contrast sensitivity than eyes without a selected amount of aberration, even though all of them received a Tecnis lens. Therefore, selecting a certain spherical aberration is important.

Today, there are several lenses with different corrections of spherical aberration available. The commercialised lenses which present corrected aberrations are: 1) Tecnis with –0.27 µm; 2) AcrySof IQ with an aberration of –0.20 µm. Other lenses are free of spherical aberrations (i.e. have spherical aberration 0). Like this, it would be possible to select the appropriate lens according to the patient’s corneal spherical aberration; the final objective would be to achieve a final total spherical aberration of +0.10 µm.

The introduction of aspheric multifocal lenses improves, as well as monofocal lenses, contrast sensitivity in comparison to spherical models. In 2008, Alcon presented the aspheric ReSTOR that provides a better quality of vision compared to the spherical ReSTOR, which maintains better contrast sensitivity and which seems to decrease undesired dysphotopsic phenomena.

Likewise, we believe that if a multifocal lens is to be implanted in glaucoma patients it should have an aspheric optic to try to compensate, as far as possible, the decrease in contrast sensitivity induced by the multifocal lens.

Nevertheless, we have to keep in mind that aspheric intraocular lenses behave better than spherical intraocular lenses as long as the decentration is lower than 0.4 mm and the tilt is lower than 7°.

The comparison of the high order aberrations in eyes between three different models of intraocular lenses with a different degree of aspheric aberration has proved that the size of the pupil, decentration, the model of the lens and the tilt angle have an influence on the high order aberrations profile. Intraocular lenses with a higher correction of spherical aberrations are more sensitive to decentration and to the changes in the size of the pupil. All the models studied show minimal high order aberrations with small pupils and
models with low or no aspheric aberrations were less sensitive to decentration and tilt.

We believe, therefore, that those eyes for which we think there is a high possibility of decentration will benefit more from neutral aspheric correction lenses and won’t be, generally, candidates for multifocal lens implantation.

**Multifocal lenses and follow-up of patients with glaucoma**

Another aspect to take into consideration is the influence of the implantation of the lens in monitoring the glaucomatous patient, i.e. in the optic nerve and visual field exam.

With regard to the visual field and in relation to the potential change in contrast sensitivity, it is advisable to repeat the visual field test after the implantation of the lens to obtain a new benchmark to monitor the patient. On the other hand, the influence of these implants on the imaging techniques that assess the papilla or the nerve fiber layer is not yet well known. A recent study shows that multifocal lenses can induce artifacts in OCT images. Even in monofocal lens implantation changes have been described in the parameters assessed by scanning laser polarimetry, although not in every study, a new study is recommended after the surgery to obtain a new level of comparison to monitor the patient.

**CONTROVERSY OVER THE MULTIFOCAL LENS IMPLANTATIONS IN PATIENTS WITH GLAUCOMA**

Patients with glaucoma are still a very controversial group for multifocal intraocular lens implantation. Controversy arises from the defects in visual function that can be induced by the disease, its evolving nature, the presence of anatomic characteristics that may not ensure the appropriate long-term centration of the lens and the potential superimposition of some shortcomings inherent in the multifocal lenses available today.

**Indication of multifocal lens in patients with glaucoma**

Nowadays, certain ocular pathologies constitute a relative contraindication for multifocal lens implantation as it is still a recent technology and some of the clinical effects that these types of lenses have can on some cases are yet unknown. Patients with glaucoma cannot be an exception to these reservations.

As both multifocal lenses and glaucoma cause a decrease in contrast sensitivity, especially under mesopic conditions, the appropriateness of implanting this type of lens in patients with this condition is a matter of controversy (Ahmed IK, Teichman JC. Point-counterpoint: cataract surgery in the glaucoma patient: don’t use a multifocal? Presented at the American Academy of Ophthalmology, Glaucoma Subspecialty Day, Atlanta GA, November 8, 2008).

The problem is further accentuated by the lack of clinical studies on the matter, as other authors have reported. Kameth believes the theoretical disadvantages of the implantation of this type of lens are not as important as it might have been expected. Nevertheless, the scant reviews that exist on literature, conclude that given the lack of studies with enough patients on the subject, no general recommendations can be made. Currently, the decision of whether to use multifocal intraocular lenses in patients with glaucoma has to be made on an individual basis.

The key is to find the balance between the decrease in contrast sensitivity we can find on glaucoma and multifocal lenses and the increase we want to achieve in quality of life (Lorente R. Catarata y Glaucoma: Elección de la lente intraocular. SEO 2010). In this respect it is important to consider two different situations in patients with glaucoma: patients with cataracts and patients with transparent crystalline, as discussed below.

**Patients with cataracts: cataract surgery with multifocal lens implantation in patients with glaucoma**

A patient with cataracts and glaucoma has a decreased functional vision in relation with both diseases. For many years visual acuity was considered a synonym for vision, but we believe that currently it is more comprehensive to use the term functional vision, as it includes visual acuity, visual field, colour perception and contrast sensitivity. The aforementioned visual functions can be altered by cataracts and glaucoma; defects associated to cataracts are reversible in most cases, unlike those of glaucoma. It is reasonable to believe that in a patient with cataracts and glaucoma, cataract surgery will improve visual function up to a level where the only limitations will be those induced by the glaucoma and the optical system implanted.

While making decisions, we accept that patients with cataracts may have progressively adjusted to a certain loss of contrast sensitivity, and therefore do not think of it as an issue for their daily life, in these cases cataract surgery per se will improve their quality of life. But in this particular case, we should also consider the potential undesired optical effects induced by the multifocal lenses. We also have to take into account that the use of lenses which reduce aberrations –such as aspheric lenses– can compensate, at least in part, the decrease in mesopic contrast sensitivity caused by multifocal implantations. And, finally, we shouldn’t ignore the patient’s motivation while selecting this kind...
of lens nor our own professionalism in creating realistic expectations regarding a specific kind of lens and, inescapably, the particular situation of a particular patient who, as well as cataracts, has glaucoma.

Taking the above into account, it is reasonable to consider the following groups as potential candidates for intraocular lens implantation (Ahmed IK, Teichman JC. Point-counterpoint: cataract surgery in the glaucoma patient: don’t use a multifocal? Presented at the American Academy of Ophthalmology, Glaucoma Subspecialty Day, Atlanta GA, November 8, 2008):

1. Patients with suspected glaucoma and with ocular hypertension without objectifiable optic nerve and visual field damage who are well monitored and stable.
2. Glaucomatous patients with mild effects in the visual field who are well monitored and stable.
3. Patients with similar levels of not severe, advanced or progressive glaucoma in both eyes.

Another aspect to be taken into account is the change of the refractive status induced by the subsequent filtering surgery, which could induce astigmatism and ocular refraction changes. It is a well-known fact that multifocal lenses are less tolerant in low ametropies than monofocal lenses and in most cases require emmetropia. Apart from the decrease in contrast sensitivity, this is another reason for advising against multifocal lens implantation in patients whose glaucoma is poorly controlled by medication or progressive.

From the structural alterations described for glaucoma that have to be taken into account when deciding whether to carry out a multifocal implant, zonular weakness plays also an important role for two reasons:

– The optical performance of the multifocal lenses is very sensitive to any decentration.
– As explained above, the implantation of aspheric lenses is advised in this kind of patients as it compensates the loss of contrast sensitivity caused by glaucoma. It is also true that aspheric lenses with decentrations over 0.5 mm, instead of decreasing high order aberrations, increase them and are not advised if there is a risk of decentration of the capsular bag.

These last considerations would mainly affect patients with pseudoexfoliative glaucoma. It is a controversial subject. While some authors believe that there is a contraindication to implanting multifocal intraocular or toric lenses in patients with glaucoma if they have zonular weakness, Ahmed does not see any inconvenience for their implantation as long as the capsular bag is correctly supported. (All about support: capsular tension devices urged for PXF patients with Peak zonales. EyeWorld September 2011. 56-57).

Reason must make its entry on our process of decision making and, in our opinion, the fact that pseudoexfoliative glaucoma is more aggressive and harder to control, making the patient more vulnerable to the decrease in contrast sensitivity, along with the problem of potential zonular weakness and the alteration of the pupil’s size and function, are enough reasons to advise against multifocal lens implantation in patients with pseudoexfoliative glaucoma.

Patients with transparent crystalline: Refractive lensectomy with multifocal lens implantation in patients with glaucoma

All the considerations discussed above for cataract patients apply to the patients with transparent crystalline, but they also present special connotations which force us to be extremely careful before considering a refractive lensectomy. We shouldn’t be particularly dogmatic in its recommendation or in rejecting it systematically. There are some true facts:

1. An angle component exists in many glaucoma patients, especially in those who are hypermetropic. Lensectomy, especially in these cases, improves the angle component favouring the intraocular pressure to drop. Although this benefit might not be as true in patients with no previous glaucoma.
2. The anterior chamber’s depth is shallow in these cases, worsening with age and caused by the progressive thickening of the crystalline.
3. Surgery on the crystalline lens can compromise the corneal endothelium in relation to a shallower anterior chamber and the hardness of the lens; the depth of the anterior chamber decreases with age, as the lens increases in volume and the lens becomes harder.
4. There are patients with a higher risk of developing acute angle closure glaucoma; this is rare in pseudopakic patients.
5. Patients with hypermetropia, unlike those with myopia, do not have a useful focal length after the age of 40-50.

According to this, refractive lensectomy should not be «not considered» in the management of glaucoma in these patients, especially in those with hypermetropia. Multifocal lens implantation can also be very attractive.

When considering a refractive lensectomy for a patient with glaucoma, the most significant differences vs. a patient with cataracts are as follows:

– Age: younger patients and therefore more difficult to predict the long-term progression of glaucoma. Likewise, they live more active lives and have more demanding visual needs in difficult situations such as night-time driving, working at intermediate to close distances and some hobbies, as well as a greater insigence on accepting certain limitations.
– Good visual acuity: with or without correction they have good distance and near vision and they will expect it to remain the same after the surgery but of course, without correction.
– Good contrast sensitivity: implies that their vision is good in spite of their incipient glaucoma and...
may, therefore, be more sensitive to a decrease in contrast sensitivity than a patient with cataracts whose vision is already poor before the surgery.

- Demands: more demanding patients in terms of the outcomes, we must be very clear about the expectations we create and the potential long-term problem which may be caused by glaucoma. We should make them understand that we are not only trying to rid them of their dependency on glasses, but also to modify the progression and possible functional deficit which may be caused by their glaucoma. The explanation and the preoperative physician-patient talk play a more important role than in glaucomatous patients.

- Motivation: are usually very motivated but we shouldn’t let ourselves be carried away by their optimism, we must be guided by our judgement and know how to refuse a patient who is not adequate.

Before making a decision, we should assess the patient’s glaucoma with regard to its concurrent disease, evolution, treatment compliance and possible role of the lens. Contrast sensitivity tests should be included in this assessment. Likewise, the long-term complications that may arise have to be clearly explained as well as the realistic expectations for the surgery.

In our opinion, we would be able to do the surgery in this typical patient: over 55-60 years, preferably a patient whose glaucoma we have been monitoring for the last few years, with good compliance and control of IOP with medication, with no or minimal alteration of the visual field, progression free for the last few years, with little loss of contrast sensitivity and with no family history of significant glaucomatous problems nor any other disease which may affect good visual acuity in the future. The patient must clearly understand the possibility of a decrease in contrast sensitivity after surgery and that this might affect quality of life.

**Choice of the multifocal lens in patients with glaucoma**

Once the decision of implanting a multifocal lens in a glaucomatous patient has been made, we must consider which implant is more adequate for a specific case.

We are talking about the more appropriate characteristics recommended for the implantation of a multifocal lens. We would like a patient with glaucoma to comply with the following requirements:

**Table 1. Spherical aberrations of different types of multifocal lenses**

<table>
<thead>
<tr>
<th>Lens</th>
<th>Spherical aberration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tecnis multifocal</td>
<td>-0.27 µm</td>
</tr>
<tr>
<td>ReSTOR SN6AD1</td>
<td>-0.10 µm</td>
</tr>
<tr>
<td>Acri.LISA</td>
<td>-0.26 µm</td>
</tr>
<tr>
<td>Lentis MPlus</td>
<td>0 µm</td>
</tr>
</tbody>
</table>

**Asphericity**

As we have discussed before, it is clear that in these cases we should implant an aspheric lens to try to compensate in a customised way the patient’s corneal spherical aberrations after a corneal aberrometry. Our aim is to achieve a postoperative ocular aberration of +0.10 µm. To this end, it is necessary to know the spherical aberrations of the different multifocal intraocular lenses (table 1).

**Contrast sensitivity**

There are no clinically significant differences in the decrease of contrast sensitivity between the different multifocal lenses. Therefore, any of them can be selected, as some loss of contrast sensitivity is inherent to all kinds of multifocal lenses.

**Type of multifocal lens**

Our selection of the type of multifocal lens can be influenced by the size of the pupil. The response of the pupil in patients with glaucoma can be modified or affected by medical treatment (pilocarpine, brimonidine, etc.) or a concurrent disease associated to glaucoma (pseudoexfoliation), therefore it would be convenient to choose a diffractive model or the new rotational asymmetrical lenses, independent of the pupil’s size in contrast to the refractive ones. However, rotational asymmetrical lenses need a 3 mm pupil minimum for near visual function to be adequate. Although, as mentioned before, we carry out the implantation in patients with a preperimetric glaucoma or ocular hypertension, who are less likely to present alterations in the pupils’ response, such alterations may develop in the future. If the size and response of the patient’s pupil is within normal ranges, we should select the type of lens following the same criteria as in a non-glaucoma patient.

**Material**

Multifocal intraocular lenses are very sensitive to posterior capsule opacities however incipient these might be. This is why in this kind of implants, we have to be demanding about the characteristics of the lens that aim to diminish the opacity of the anterior capsule: hydrophobic acrylic, square edge.

**Design**

Given the higher incidence of capsular contraction and phimosis in glaucomatous patients due to a rupture in the hemato-aqueous barrier (pseudoexfoliation) and the smaller capsulorhexis common in these cases due to
a worse intraoperative dilation, it is convenient to avoid the implantation of plate-design lenses that increase the risk of anterior capsule fibrosis.

To sum up, it is important to implant an aspheric, acrylic, hydrophobic lens to ensure a big enough capsule-lorhexis and to avoid plate-like designs in patients with high risk of capsular contraction. A capsular ring may also be advisable, as amongst other things, it would facilitate the removal of the lens if it were necessary.

Other options

The recent emergence of lenses for piggyback implantation into the sulcus offers a new option to take into account in these cases. Gerten has published some primary piggybacks implanting a monofocal lens in the bag and a +3.50 D at lens plane diffractive lens with zero power in the sulcus. One of the advantages of this dual implantation is that the lens in the sulcus can be removed if the patient is dissatisfied with the multifocal lens implantation, or if an initially satisfied patient develops a concurrent disease where the multifocal implant constitutes a burden. The study included 56 eyes from 30 patients; patients with concurrent ocular disease were excluded. Although this study presents a new option, there are no long-term safety data on the primary piggyback in the sulcus in patients with glaucoma. Piggyback contraindications in patients with glaucoma include, amongst others, pigment dispersion syndrome, zonular weakness and low endothelial cell count, all of which can be present in glaucomatous patients.

Another alternative for multifocal lenses are accommodative lenses, which might be better suited for patients with ocular disease as it seems that they do not decrease contrast sensitivity. Nevertheless, this hypothesis has not yet been contrasted in clinical studies with glaucomatous patients. The potential advantages of theses lenses with regard to multifocal lenses are: 1) They behave as a monofocal lens with good visual acuity for intermediate and distance vision; 2) Minimises dysphotopsic effects; 3) are not pupil-size dependent; and 4) As already mentioned, the most important thing is that it doesn’t cause a decrease in contrast sensitivity thus not interfering in the longer term with glaucoma. This would make them ideal lenses, but they have the following drawbacks: 1) Worse near vision; 2) Great difference in the outcomes between patients, outcomes that depend on the axial length, the power of the lens and corneal power amongst other factors; 3) Refractive instability, decreasing the accommodative effect over time; 4) Some intrinsic complications as a higher risk of capsular contraction causing syndrome Z; and 5) Probably, the higher risk of capsular opacification with regard to square edged hydrophobic lenses.

On top of this, these lenses require an intact accommodative system, which fails in pseudoexfoliation patients and frequently in glaucomatous patients, in order to work. As it is a relatively new technology, we can expect some of them to improve with the new designs. In any case, it is obvious that we need more clinical studies to assess their behaviour in the eye.

CONCLUSIONS

Multifocal lens implantation in glaucomatous patients is controversial and literature on the subject is scarce. On the one hand, patients with glaucoma have certain functional (decrease in contrast sensitivity) and structural characteristics that may interfere in the optimal performance of a multifocal implantation. On the other hand, the new models of multifocal lenses, which include spherical lenses, can counteract the potential decrease in contrast sensitivity induced by the multifocal lens, patients with cataracts are already adjusted to some decrease in sensitivity. The scarce literature in relation to this matter does not evidence worse outcomes in glaucomatous patients than in those who have received a multifocal lens. Taking all of this into account, a multifocal implant in glaucomatous patients would be possible in motivated patients with a well-controlled glaucoma, with mild or no defects in their visual field and similar stage of affection in both eyes. All this requires an exhaustive preoperative exam and adequate patient information.

REFERENCES


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