8 Multifocal Intraocular Lenses: Complications

Roberto Fernández Buenaga and Jorge L. Alió

8.1 Introduction

Implantation of multifocal IOLs that offer full refractive correction at all distances is the ideal goal for cataract and lens-based refractive surgery. Overall, multifocal IOLs achieve high patient satisfaction [1, 2]. Other studies also show a high patient satisfaction after multifocal IOLs surgery with scores of 8.3 ± 1.6 (out of 10) and 8.5 ± 1.2 (out of 9), respectively [3, 4].

In a paper from our research group, we found correlations between some clinical parameters and the quality of life, such as driving (especially at night) and contrast sensitivity or eyesight quality and uncorrected distance visual acuity [5].

In a very recent publication, an interesting correlation between positive dysphotopsia complaint and personality type was found. In this study, 82.2% of the patients would opt for a multifocal IOL again, 3.7% would not, and 14.1% were uncertain. Overall satisfaction with the procedure was correlated to low astigmatism, good visual performance, low halos and glare perception, and low spectacle dependence. The personality characteristics of compulsive checking, orderliness, competence, and dutifulness were statistically significantly associated with subjective disturbance by glare and halos [6].

Multifocal IOL explantation represents the main failure of the intended surgery. It is always disappointing for both patient and surgeon. Furthermore, IOL explantation surgery is not always easy to be performed, and it is not exempt from new complications. Because of all these reasons, multifocal IOL explantation should be only performed when there is no other alternative and all the causes leading to patient dissatisfaction have been properly ruled out.

Thus, it is essential for the multifocal IOL surgeon to know and to investigate the main causes leading to patient dissatisfaction after cataract surgery because, in most of the cases, the situation can be successfully managed with no need of new intraocular surgeries.

In this chapter, we will review the main reasons for patient unhappiness after multifocal implantation surgery, and we will show the strategies to manage each situation. We will also describe the multifocal IOL explantation incidence and recommendations. Instructions for the IOL explantation surgery will be also given.

R. F. Buenaga (✉)
Department of Cornea, Cataracts and Refractive Surgery, Vissum Corporation, Madrid, Spain

J. L. Alió
Research & Development Department and Department of Cornea, Cataract, and Refractive Surgery, VISSUM Corporation and Miguel Hernández University, Alicante, Spain

J. L. Alió, J. Pikkel (eds.), *Multifocal Intraocular Lenses*, Essentials in Ophthalmology,
https://doi.org/10.1007/978-3-030-21282-7_8

8.2 Prevention

Patient selection is a key factor in multifocal IOL surgery success. Two different aspects should be considered. First, patient expectations should match the outcome that will be achieved with multifocal IOL. In addition, some personalities are more likely to tolerate the multifocal IOL pitfalls than others; therefore, patient personality should be analyzed too. Second, a thorough eye examination is mandatory in order to rule out conditions that may affect the multifocal IOL performance such as binocularity issues, optic nerve or macular disorders, amblyopia, etc.

Multifocal IOL type selection is the other key factor for success. There are many different multifocal IOL models and designs. It is therefore very important to investigate the lifestyle of each patient to have an overview of the most common visual demands in order to choose the IOL design that is more likely to satisfy those demands.

These aspects regarding preoperative considerations are discussed in greater detail in the specific chapter.

8.3 Reasons for Patient Dissatisfaction

8.3.1 Blurred Vision

Blurred vision is the leading cause of dissatisfaction among patients with multifocal IOLs [7]. Woodward, Randleman, and Stulting reported that blurred vision was the main complaint in 30 patients (41 eyes), out of 32 patients (43 eyes). Fifteen patients (18 eyes) reported photic phenomena, and 13 patients (16 eyes) reported both blurred vision and photic phenomena. The etiology of blurred vision was attributed to ametropia and PCO in the majority of cases. Despite overall success with less invasive interventions, 7% of eyes required IOL exchange to resolve symptoms [7].

In a different study focused on the same issue, blurred vision (with or without photic phenomenon) was reported in 72 eyes (94.7%) and photic phenomena (with or without blurred vision) in 29 eyes (38.2%). Both symptoms were present in 25 eyes (32.9%). Residual ametropia and astigmatism, posterior capsule opacification, and a large pupil were the three most significant etiologies. Intraocular lens exchange was performed in three cases (4.0%) [8].

Dissatisfaction after multifocal IOL implantation is reported by patients who do not achieve the desired visual goals, have limited sharpness of vision, or have new visual aberrations. A Cochrane review about multifocal IOLs found that photic phenomena are 3.5 times more likely with multifocal IOLs than with monofocal IOLs [9].

Most of the times, there is an identifiable reason. In a publication mentioned above, it was shown that causes of blurred vision included ametropia (29% of cases), dry eye (15%), posterior capsule opacification (PCO) (54%), and unexplained etiology (2%). Regarding the photic phenomena, its causes included IOL decentration (12%), retained lens fragment (6%), PCO (66%), dry eye (2%), and unknown etiology (2%). In this paper, the authors achieved an improvement in 81% of eyes with conservative treatment [7]. In a similar study, 84.2% of eyes were amenable to therapy, with refractive surgery, spectacles, and laser capsulotomy as the most frequent treatment modalities [8].

In a very recent paper over more than 9300 eyes implanted with a multifocal IOL, patient satisfaction was very high: 93.8% of the patients reported to be satisfied or very satisfied, while only 1.7% of the patients were dissatisfied or very dissatisfied [10].

8.3.2 IOL Decentration

Several clinical studies have determined the decentration of IOLs after cataract surgery [11–21]. In general, the mean decentration (after uneventful cataract surgery) in the studies is 0.30 ± 0.16 mm (range 0–1.09 mm). When a multifocal IOL is displaced from its center, it may lose its ability to achieve optimal optical properties thus decreasing the visual function (Fig. 8.1). There are three main factors that

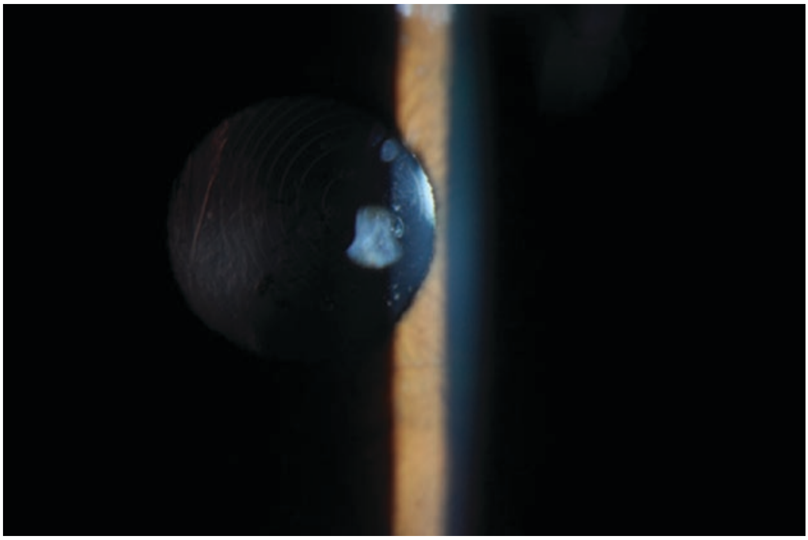


Fig. 8.1 This picture shows a diffractive IOL decentered nasally

determine how visual function is affected by IOL decentration:

- The degree of decentration
- The IOL design
- Pupil size

In a recent study of four different multifocal IOL models (two diffractive and two refractive), performance was studied at increasing degrees of decentration in an eye model with a 3 mm pupil. For the ReSTOR (+4), the near MTF (modulation transfer function) deteriorates with increasing degrees of decentration, while the far MTF tends to improve. This is explained by the specific design of this IOL with a monofocal design in its peripheral part. In other IOL models like the ZM900, the entire optical surface has a diffraction structure; therefore a slight decrease in both far and near MTF starting at decentrations of 0.75 mm was observed. For the refractive models (ReZoom and SFX-MV1), even when the decentration was 1 mm, the near MTF did not change; however, the far MTF decreased starting at decentrations of 0.75 and 1 mm, respectively. In conclusion, the MTFs and near images are affected, but clinical relevant effects are not to be expected up to a decentration of 0.75 mm using this eye model with a 3 mm pupil and the previously mentioned IOLs [22].

In a different study comparing refractive multifocal and monofocal IOL performance depending on the pupil size and decentration, it was found that in the multifocal group, smaller pupils correlated with worse near visual acuity, while decentration was significantly correlated with worse distance and intermediate visual acuity. However, in the monofocal group, pupil size and IOL decentration did not affect the final visual acuity [23].

It has been also shown by other authors that the more sophisticated the IOL is, the more sensitive to decentration it is. In a paper comparing aberration-correcting, aberration-free, and spherical IOLs, after decentration, the performance of the IOL was more affected in the aberration-correcting group followed by the aberration-free IOLs, while the spherical IOLs were not affected by decentration at all [24].

Another interesting consideration is the Kappa angle. Although it is not very common, some patients may have a large Kappa angle. It should be suspected and checked in every patient with a perfectly pupil-centered multifocal IOL but with poor vision complaint [25].

The main symptoms when multifocal IOL decentration occurs are the photic phenomena including glare and halo. A suboptimal visual acuity is also detected in these cases.

Management The first important message is that multifocal IOL decentration that occurs after an uneventful cataract surgery can be managed without IOL explantation in the majority of the cases. We advocate performing Argon laser iridoplasty as the treatment of choice. The Argon laser settings for the iridoplasty are 0.5 s, 500 mW, and 500 µm. Other authors have also recommended this approach (E.D. Donnenfeld, MD, et al., "Argon Laser Iridoplasty to Improve Visual Function After Multifocal IOL Implantation," presented at the ASCRS Symposium on Cataract, Intraocular Lens and Refractive Surgery, Chicago, Illinois, USA, April 2008). Obviously, this is a valid strategy only in cases with pupil-decentered IOLs but not when the problem is a large Kappa angle. As discussed before, a large Kappa angle is an important contributor to the photic phenomenon. This cannot be solved after the surgery (except by means of an explantation); thus it is very important to study the Kappa angle prior to the surgery, and those patients with large angle should be excluded from multifocal surgery [26, 27].

8.3.3 IOL Tilt

The material and biocompatibility of the haptics have been shown to play a role in IOL centration [28, 29]. Hydrophilic IOLs have several advantages because of its pliable and scratch resistance nature that allows to implant these IOLs through small corneal incisions. However, this malleable material may be a major drawback if capsular bag contraction develops. The combination of hydrophilic material with soft C-loop haptics may facilitate IOL decentration and tilt when capsule bag contraction starts to develop. Rotationally asymmetric refractive IOLs are sensitive to decentration and tilt because of their inherent design characteristics [30, 32].

As a research group, we have several publications on this issue especially regarding our experience with the Oculentis Mplus IOL [31, 33]. There were two different versions of the Lentis Mplus: the LS-312 and the LS-313. The former one was the first to be marketed, and it had a C-loop design, while the latter is the current one and has a plate-haptic design (Fig. 8.2).

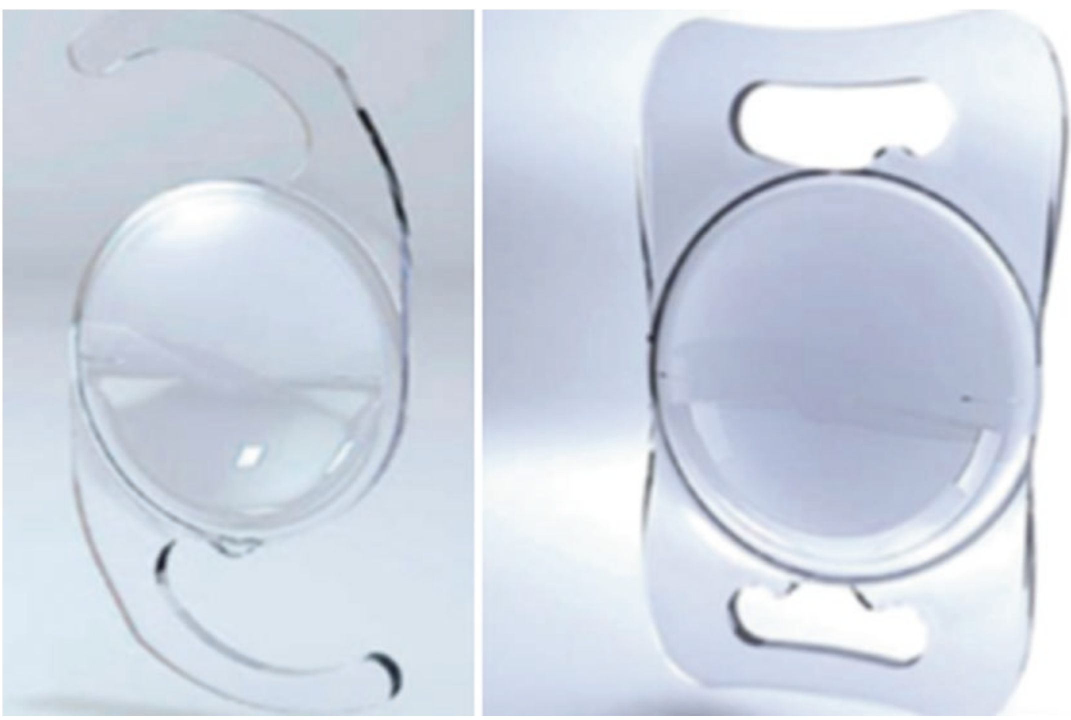


Fig. 8.2 C-loop design (LS-312) on the left and plate-haptic design (LS-313) on the right

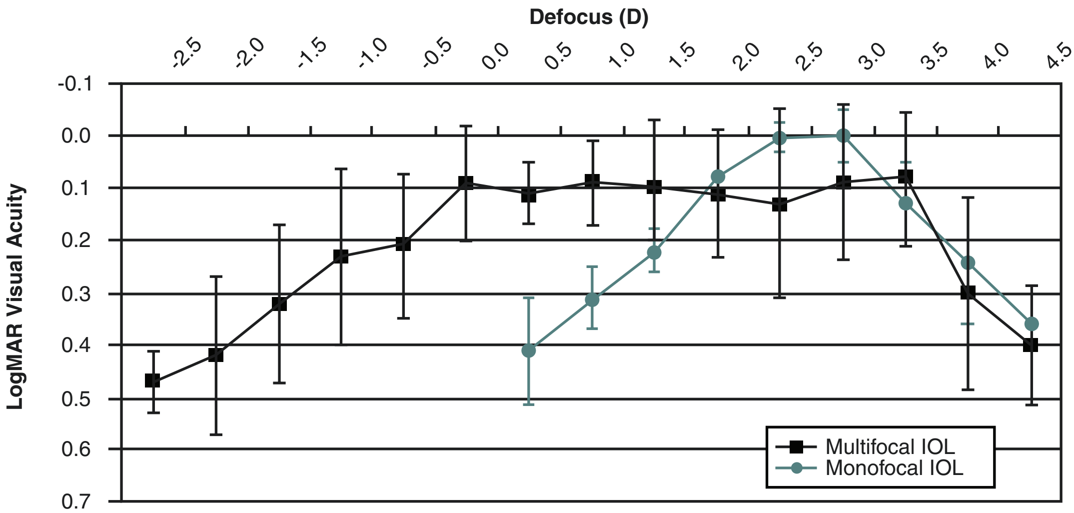


Fig. 8.3 Mean defocus curves (IOL intraocular lens)

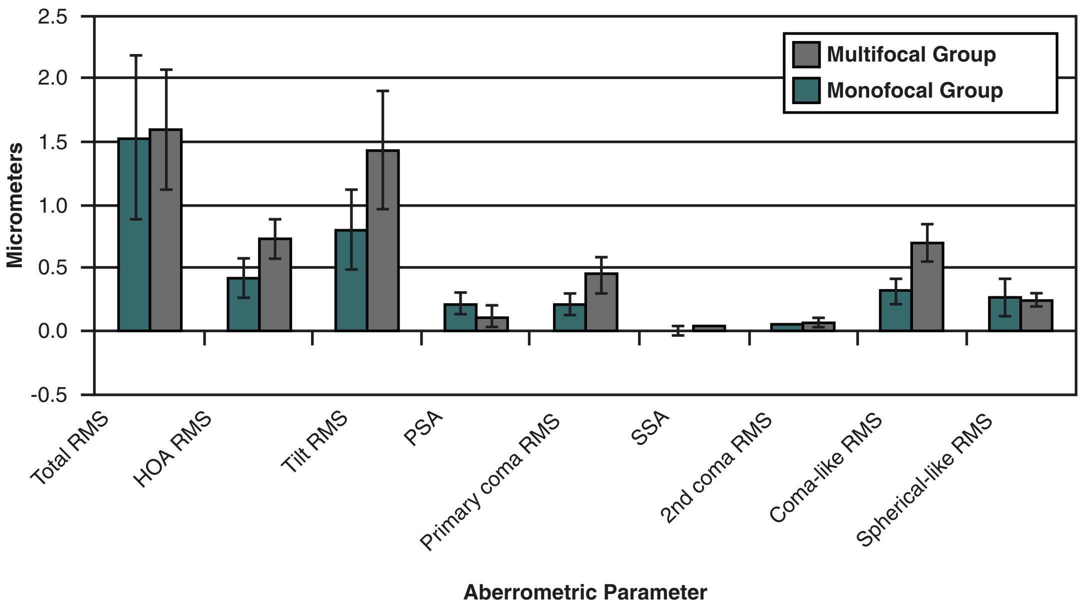


Fig. 8.4 Mean (±SD) postoperative intraocular aberrations with a 5.0 mm pupil (second coma, secondary coma; HOA higher-order aberration, IOL intraocular lens, PSA primary spherical aberration, RMS root mean square, SSA secondary spherical aberration)

Our research group published the first paper evaluating this IOL performance in vivo and comparing it with a monofocal spherical IOL [31]. We found that the Lentis Mplus LS-312 effectively restored the near visual acuity with also very good levels of intermediate vision showing a very good defocus curve (Fig. 8.3). It was discussed in this manuscript that it is intrinsic to this IOL design to induce primary vertical coma, and this could be related to the increased depth of focus found in this group of eyes. However, primary coma, especially in larger amounts, has a very negative impact on visual acuity because it induces optical blur. Furthermore, in this study, the multifocal IOL group had larger amounts of intraocular tilt (Fig. 8.4). This suggested that the Lentis Mplus LS-312 might be tilted and perhaps decentered in the capsular bag in a significant number of cases. We found a strong and significant correlation between IOL tilt and increased primary coma. Although, as previously commented, primary coma could have a positive effect on the depth of focus, large amounts of this aberration due to the IOL tilting caused significant degradation of the retinal image. Therefore, the near vision outcomes seemed to be significantly limited by the increase of primary coma in cases of IOL tilt.

Capsular tension rings (CTR) have been shown to inhibit posterior capsule opacification [34], play a role in the stability and positioning of IOLs [35], and prevent IOL movements caused by capsular bag contraction [36–38].

Based on the outcomes showed in the previous paper, we decided to conduct another study to ascertain whether the use of a capsular tension ring positively affects the refractive and visual outcomes as well as the intraocular optical quality of eyes implanted with the rotationally asymmetric multifocal Lentis Mplus LS-312 IOL (Oculentis GmbH, Berlin, Germany). We compared two different groups of patients, one group with the Mplus LS-312 plus CTR and the second group implanted without CTR. It was found that refractive predictability and intermediate visual outcomes with the Lentis Mplus LS-312 IOL improved significantly when implanted in combination with a capsular tension ring. However, no significant differences were observed in the optical quality analysis between groups [33].

Due to all these inconveniences discussed above, Oculentis GmbH, Berlin, Germany, decided to introduce a new plate-haptic design for the Mplus IOL, the LS-313, in an attempt to achieve a greater IOL stability when capsular bag contracts. We conducted another study to check whether that purpose was achieved with the new design [32]. Significantly better visual acuities were present in the C-loop haptic with CTR group for the defocus levels of −2.0, −1.5, −1.0, and − 0.50 D (P = 0.03) (Fig. 8.5). Statistically significant differences among groups were found in total intraocular root mean square (RMS), high-order intraocular RMS, and intraocular coma-like RMS aberrations (P = 0.04), with lower values from the plate-haptic group (Fig. 8.6). However, it is interesting to notice that when we analyzed the intraocular tilt aberrations, no significant differences between groups were detected. Thus, our findings indicate that it is unclear which IOL haptic design allows more effective control of IOL tilting.

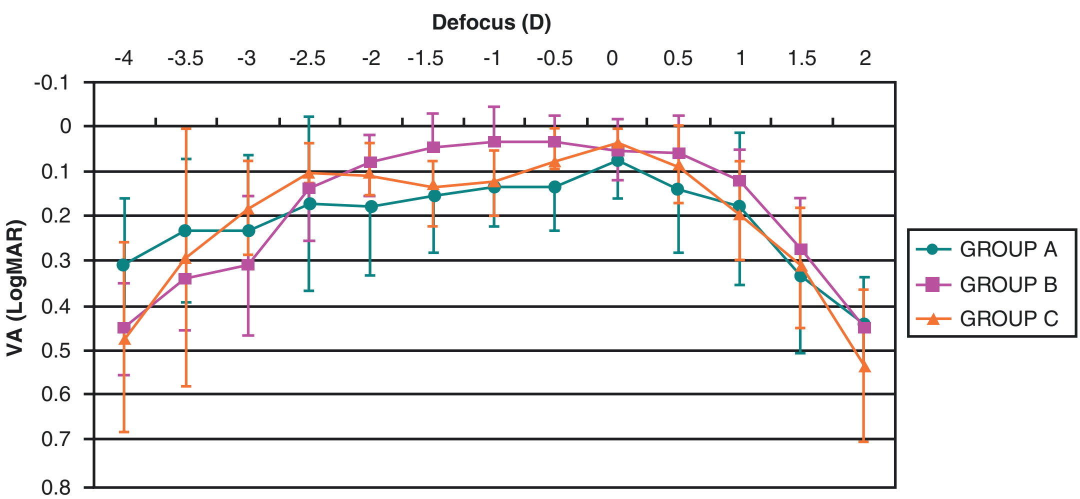


Fig. 8.5 Mean defocus curve in the three groups of eyes analyzed: group A, eyes implanted with the C-loop haptic design of the refractive rotationally asymmetric multifocal intraocular lens (MIOL) without using a capsular tension ring (CTR) (green line); group B, eyes implanted with the C-loop haptic design of the refractive rotationally asymmetric MIOL using a CTR (pink line); and group C, eyes implanted with the plate-haptic design of the refractive rotationally asymmetric MIOL (orange line)

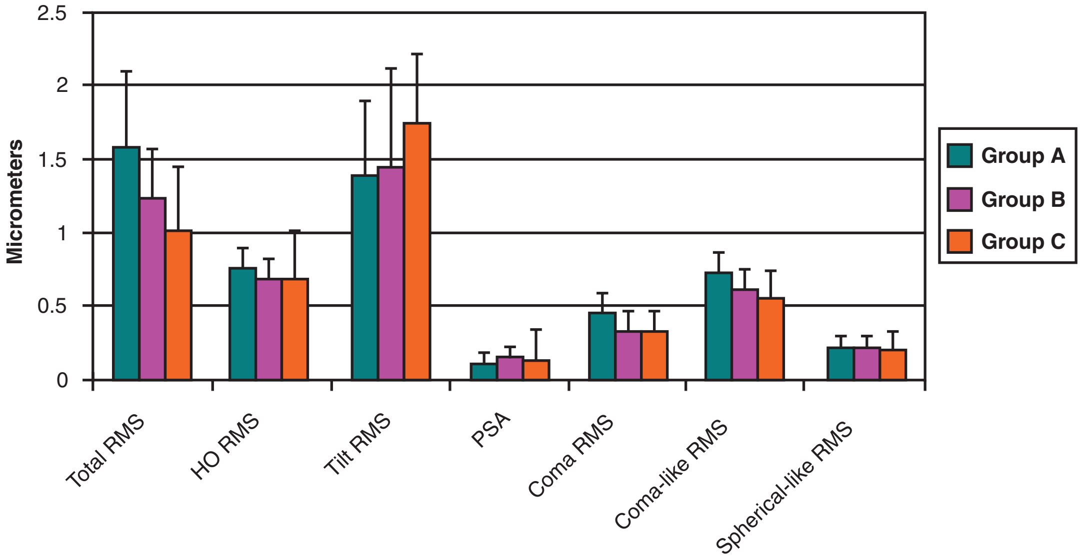


Fig. 8.6 Postoperative intraocular aberrations in the three groups of eyes analyzed: group A, eyes implanted with the C-loop haptic design of the refractive rotationally asymmetric multifocal intraocular lens (MIOL) without using a capsular tension ring (CTR) (green bars); group B, eyes implanted with the C-loop haptic design of the refractive rotationally asymmetric MIOL using a CTR (pink bars); and group C eyes implanted with the plate-haptic design of the refractive rotationally asymmetric MIOL (orange bars). RMS values (in micrometers) and standard deviation of total, higher order, tilt, and spherical-like and coma-like aberrations. In addition, the primary spherical aberration is also reported with its sign. RMS root mean square, HO higher order, PSA primary spherical aberration, SSA secondary spherical aberration

To summarize, IOL tilt due to capsular bag contraction is more prone to occur in lenses made of soft materials especially in combination with C-loop haptics. IOL tilt determines increased high-order optical aberrations; thus poorer optical quality and limited performance also related to a worse refractive predictability. IOL tilt should be prevented using robust IOL designs resistant to the normally occurring capsular bag scarring.

We advocate to implant capsular tension rings in every multifocal IOL surgery, and there are two different justifications for this: first, because it helps to avoid IOL decentration in the long term due to the capsular bag scarring and, second, because it makes much easier to perform an eventual IOL explantation surgery.

8.3.4 Inadequate Pupil Size

Postsurgical pupil size is a very important parameter that definitely determines the IOL performance. The main challenge regarding this issue is that it is very difficult to predict the pupil size that will be found after the surgery because it usually changes in comparison with the preoperative measurements. Thus, a very small pupil after the surgery will limit the near vision performance of most of the multifocal lenses, especially the refractive ones because diffractive IOLs are more pupil-independent. On the other hand, large postoperative pupils are associated with increased photic phenomena referred by the patients.

Visual acuity correlates with pupil size; a larger pupil permits greater use of the multifocal IOL optic with zonal models and improved contrast sensitivity with diffractive models [23, 39].

Management

– In patients with poor near vision outcomes due to very small pupils, we advocate to use cyclopentolate to enlarge the pupil; if a clear improvement is noticed, the patient may keep using the cyclopentolate as described by other authors [7], or an 360° Argon iridoplasty (0.5 s, 500 mW and 500 μm) might be considered.

– The other side of the spectrum is comprised of patients with too large pupils who complain of increased photic phenomena. In these cases, brimonidine tartrate 0.2% to decrease mydriasis at night is a classical solution in refractive surgery that has been also recommended by other authors [7, 40, 41]. It decreases the pupil size, thus improving the photic phenomena at night.

8.3.5 Residual Refractive Error

As multifocal IOLs are more sophisticated lenses, they are also more sensitive to any residual refractive error.

Despite new advances in cataract surgery, unsatisfactory visual outcomes as a result of a residual refractive error occasionally occur. In a report analyzing refractive data from more than 17,000 eyes after cataract surgery, it was shown that emmetropia was only reached in 55% of eyes planned for that goal [42]. These outcomes highlight that refractive error after cataract surgery is an important issue.

Postoperative refractive errors may be due to different causes, such as inaccuracies in the biometric analysis [43–45], inadequate selection of the IOL power, limitations of the calculation formulas especially in the extreme ametropia, or IOL positional errors [46].

Previous studies have shown good efficacy, predictability, and safety for myopic and hyperopic laser in situ keratomileusis (LASIK) and photorefractive keratectomy (PRK) enhancements after cataract surgery [47–53]. Lens-based procedures are also useful alternatives to consider [54, 55]. It should be noticed that some surgeons do not have excimer laser in their centers; thus lens procedures become the only possible option in these cases. We conducted a study which its aim was to present and compare the results assessing the efficacy, predictability, and safety of three different procedures to correct residual refractive error after cataract surgery: LASIK, IOL exchange, and piggyback lens implantation. Although this study only included monofocal IOLs, the outcomes could be extrapolated to multifocal IOLs. The results of this study showed that the three procedures were effective, but LASIK achieved the highest efficacy index, the best predictability with 100% of the eyes within ±1 diopters of final spherical equivalent, and 92.85% of eyes showed a final SE within ±0.50D (Figs. 8.7 and 8.8). The LASIK also showed lower risk of losing lines of corrected vision compared with the other two procedures [56].

Regarding laser enhancement after multifocal IOL implantation, some authors have reported improvement in distance vision with limited effect on photic phenomena after PRK retreatments in patients implanted with refractive multifocal IOLs [48], while others have reported excellent predictability in patients implanted with apodized diffractive/refractive and diffractive IOLs [47, 57].

In other study performed by our research group, we evaluated efficacy, predictability, and safety of LASIK to correct residual refractive errors following cataract surgery, comparing the outcomes of patients implanted with multifocal and monofocal IOLs. We found that laser in situ keratomileusis refinement after cataract surgery with monofocal IOL implantation provides a more accurate refractive outcome than after multifocal IOL implantation. Predictability of LASIK correction is limited in hyperopic eyes implanted with multifocal IOLs (Figs. 8.9, 8.10, 8.11, and 8.12) [53].

In summary, residual refractive error is one of the most common reasons for patient complaints after cataract surgery with multifocal IOL implantation. Hence, it is extremely important to make sure prior to the cataract surgery with multifocal IOL implantation that the patient has normal topography and pachimetry that will permit a laser enhancement in case that we need it.

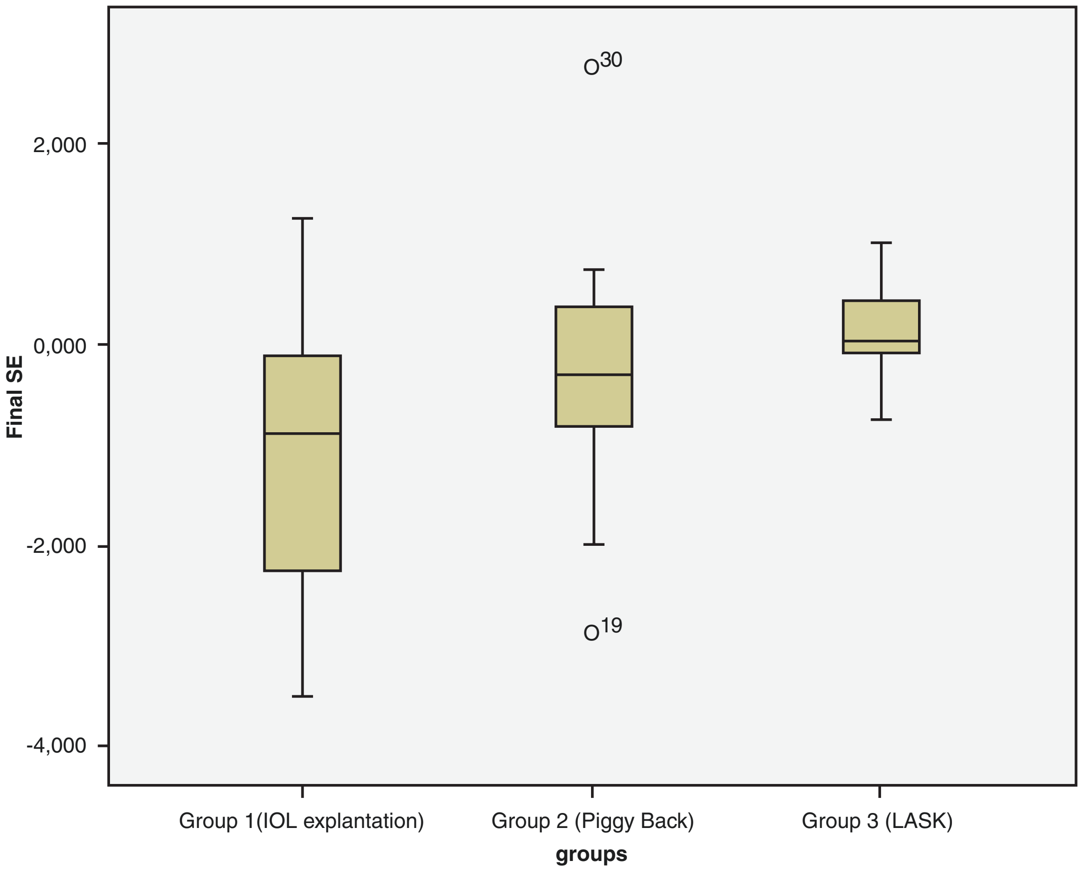
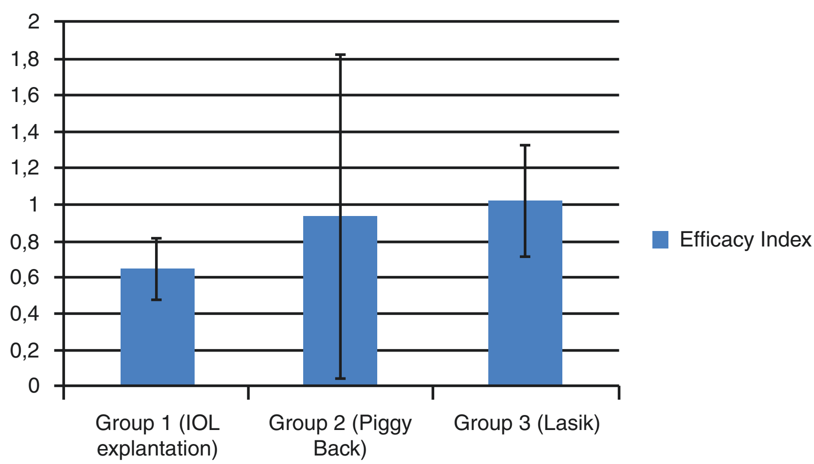


Fig. 8.7 Comparison of the final spherical equivalent (SE) among the three groups. Group 3 (LASIK) achieved the best outcome with the smallest results dispersion

Fig. 8.8 The efficacy index mean and distribution among groups. The highest value was achieved by group 3 (LASIK)



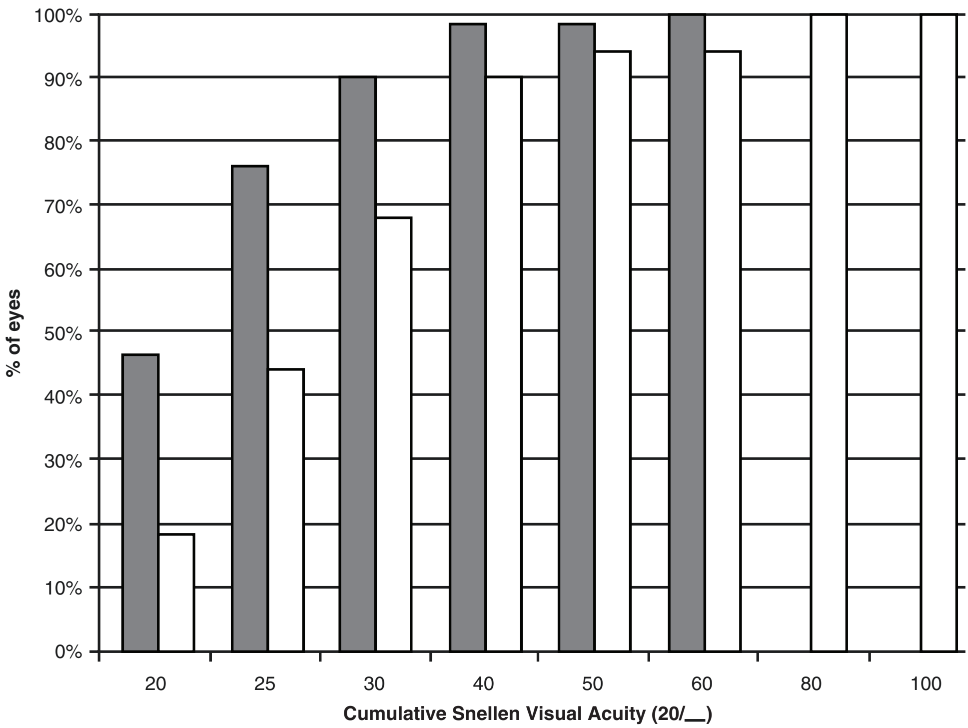


Fig. 8.9 Distribution of postoperative uncorrected distance visual acuity outcomes (UDVA) (white bars) compared to preoperative distribution of corrected distance visual acuity (CDVA) (gray bars) in the multifocal group (50 eyes). Uncorrected distance visual acuity was 20/40 or better in 90% of eyes and 20/25 or better in 44% of eyes

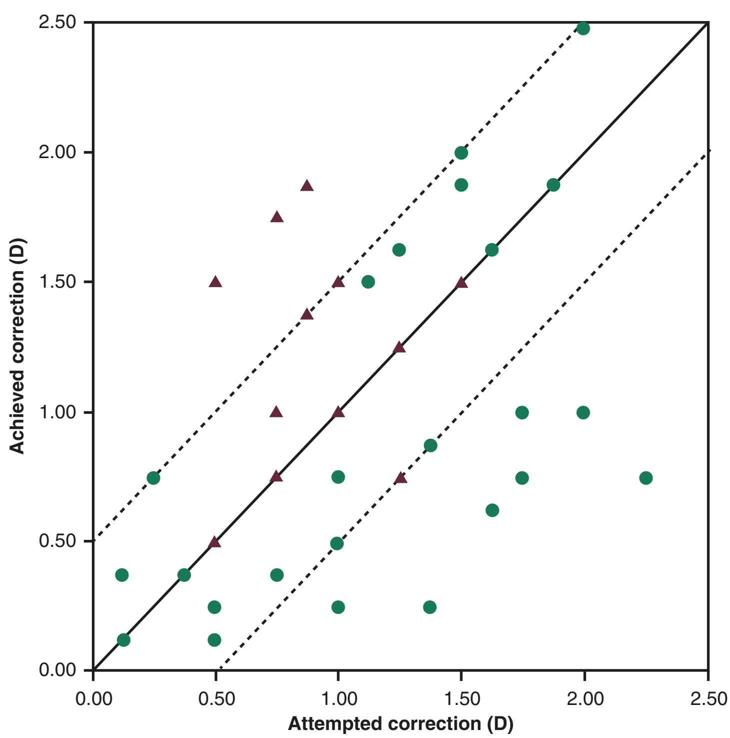


Fig. 8.10 Scattergram of attempted versus achieved correction for the multifocal group (50 eyes). Green circles represent hyperopic cases, whereas red triangles represent myopic cases. A tendency for undercorrection was noted in eyes that underwent hyperopic LASIK after multifocal IOL implantation. Dashed lines represent ±0.50 D from the 1:1 line

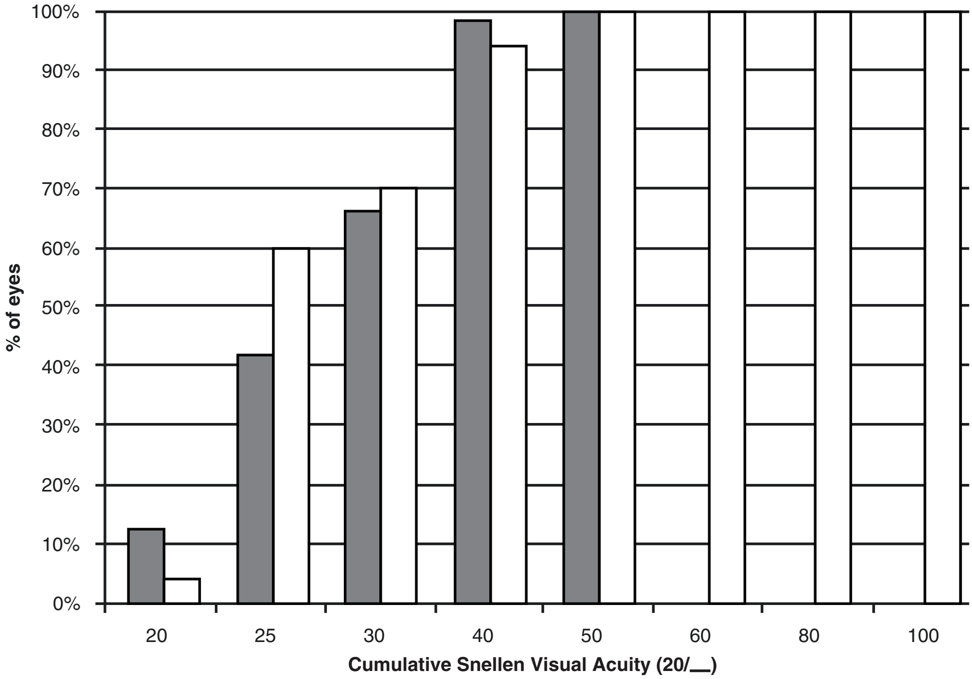


Fig. 8.11 Distribution of postoperative UDVA outcomes (white bars) compared to preoperative distribution of CDVA (gray bars) in the monofocal group (50 eyes). Uncorrected distance visual acuity was 20/40 or better in 94% of eyes and 20/25 or better in 60% of eyes

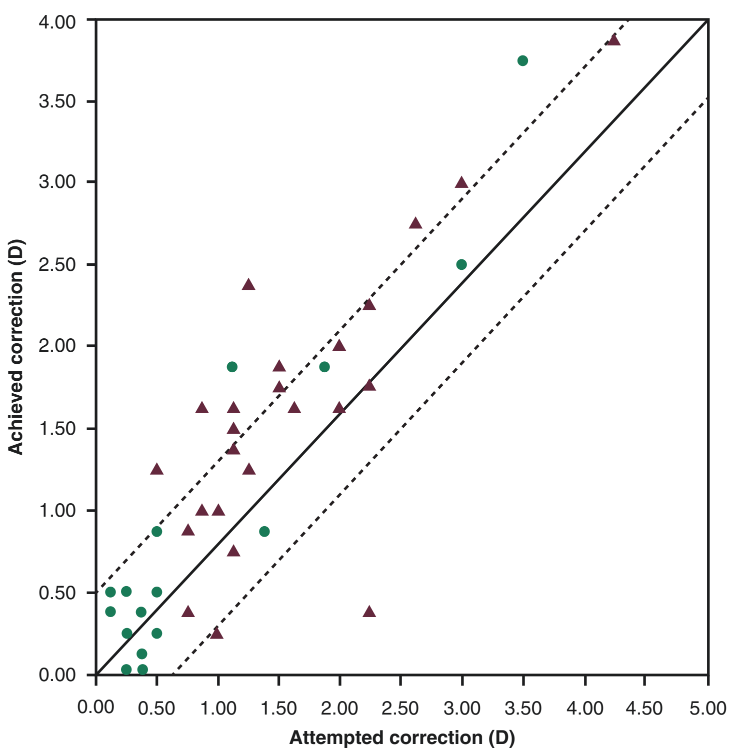


Fig. 8.12 Scattergram of attempted versus achieved correction for eyes from the monofocal group (50 eyes). Green circles represent hyperopic cases, whereas red triangles represent myopic cases. Predictability was good with almost all eyes within ±1.00 D of spherical equivalent refraction. The dashed lines represent the ±0.50 D range from the 1:1 line

8.3.6 Posterior Capsule Opacification

The most common long-term complication of IOLs implanted is posterior capsule opacification (PCO) [58–60]. Patients with PCO complain of decreased visual acuity, contrast sensitivity, and increased photic phenomena like glare. The treatment is fast and safe using the Nd:YAG laser. However, although rarely, there may be some associated complications like optic IOL damage, intraocular pressure rise, cystoid macular edema, and retinal detachment increased risk [61]. Furthermore, the procedure has a noticeable economical impact (250 millions of dollars/per year in the USA).

A Cochrane review [62] showed significantly higher PCO rates after hydrogel IOL implantation than after implantation of IOLs of other materials, significantly lower PCO rates with sharp posterior optic edge IOLs than with round-edged IOLs, no difference between 1-piece and 3-piece IOLs, lower PCO rates with IOLs placed in the capsular bag than in the sulcus, and lower PCO rates in eyes with a small capsulorhexis than with a large capsulorhexis.

PCO is especially important in multifocal IOLs because due to more sophisticated design and the higher visual demands, these lenses might be more sensitive to PCO than the monofocal ones. Indeed, in a study comparing the frequency of posterior capsulotomies in patients receiving a multifocal or monofocal intraocular lens (IOL) of a similar design, it was shown that the use of multifocal IOLs in clinical practice may result in more frequent Nd:YAG laser capsulotomies. After average 22-month postoperative follow-up (range: 2–41 months), 15.49% of eyes in the multifocal group underwent posterior capsulotomies compared to 5.82% of eyes in the monofocal group [63].

The main complaints in patients with multifocal IOLs implanted and PCO are blurred vision and increased photic phenomena [7]. In fact, in this study, blurred vision and photic phenomena were attributed to PCO in 54% and 66% of eyes, respectively.

Other authors have studied the capsulotomy rate after the implantation of different multifocal IOL models to see if there is a difference in this rate related to the IOL material or design. The authors compared a hydrophobic lens (AcrySof ReSTOR) with a hydrophilic IOL (Acri.LISA), and they found that 24 months after the surgery, the capsulotomy rates were 8.8% in the hydrophobic group and 37.2% in the hydrophilic group ($P < 0.0001$). Eyes in the hydrophilic group had a 4.50-fold (2.28 versus 8.91) higher risk for Nd:YAG laser capsulotomy ($P < 0.0001$) [64].

In another paper, the authors conducted a comparison between two trifocal IOLs (the FineVision MicroF (PhysIOL, Liège, Belgium) or AT Lisa tri 839MP (Carl Zeiss Meditec, Jena, Germany) implanted in over 5.000 eyes. The probability of having a YAG capsulotomy was equal up to 9 months after the surgery. However, beyond this point, the incidence was higher for the AT Lisa tri with 35% at 34–44 months compared with 14% at 37–47 months for the FineVision [65].

Management It is evident that the best treatment to resolve a PCO is Nd:YAG laser capsulotomy. However, we encourage surgeons to reserve Nd:YAG capsulotomy until all other causes of patient complaints are treated or ruled out. Although IOL exchange is necessary in rare cases, it is significantly more challenging and associated with a higher risk of complications when the posterior capsule has been previously opened. Surgeons should be especially aware of patient complaints arising from elements intrinsic to IOL design, which should generate complaints in the immediate postoperative period before PCO formation.

8.3.7 Photic Phenomena and Contrast Sensitivity

In a very recent literature review about multifocal IOL benefits and side effects, photic phenomena were detected as one of the most important drawbacks after multifocal IOL implantation [66]. Halos and glare (Fig. 8.13) are more often reported by patients with a multifocal IOL than with a monofocal IOL [67, 68].

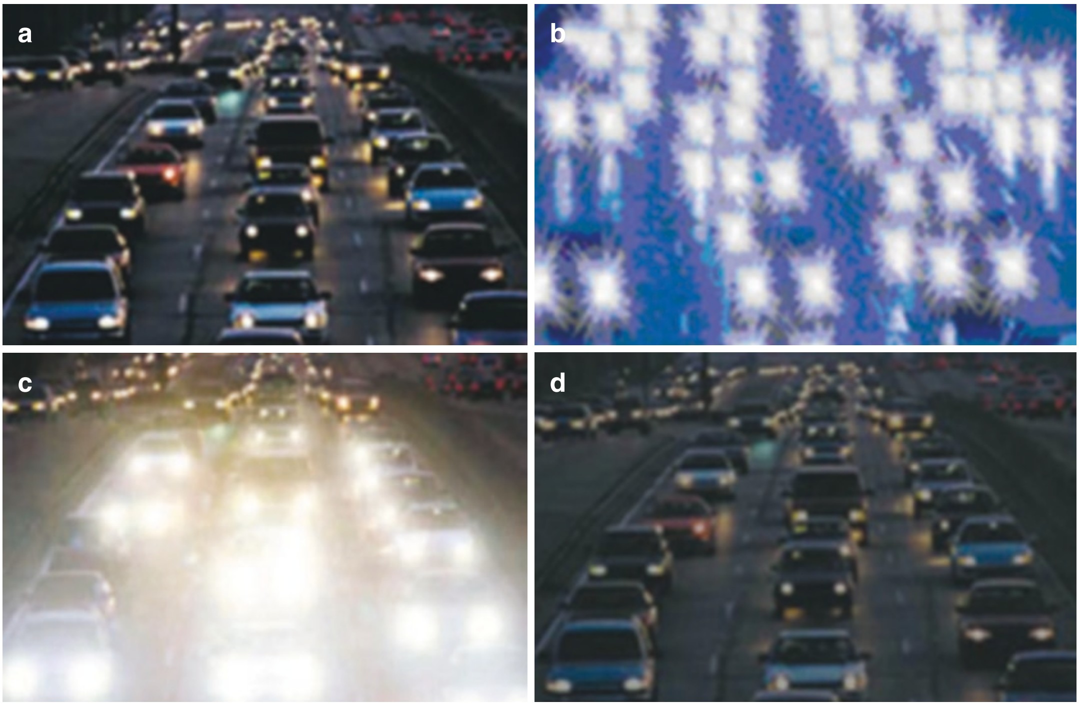


Fig. 8.13 (**a**) Normal image is shown up on the left. (**b**) Image with glare is shown up on the right. (**c**) Down on the left: halos. (**d**) Down on the right: contrast sensitivity loss

Refractive multifocal IOLs appear to be associated with more photic phenomena than diffractive multifocal IOLs [2]. Photic phenomena are among the most frequent reasons for dissatisfaction after multifocal IOL implantation [7, 8].

Photic phenomena are also significant with the new trifocal IOL models. In fact, there are some studies which analyze the area of light distortion induced by trifocal IOLs in comparison with monofocals. This area of light distortion is almost twice bigger in trifocals when compared with monofocals [69, 70].

Multifocal IOLs are associated with lower contrast sensitivity than monofocal IOLs [70], especially in mesopic conditions [71]. In a very recent paper, it has been demonstrated that patients with a diffractive multifocal IOL have a relevant reduction in contrast sensitivity as assessed with standard automated perimetry for size III and size V stimuli in comparison with phakic patients and with monofocal implanted patients [72].

An explanation for the lower contrast sensitivity could be that multifocal IOLs result in coexisting images, because the light is shared between two (or more) different foci. Therefore, there are two images, one sharp and one out of focus, with the light from the latter reducing the detectability of the former image. Diffractive multifocal IOLs appear to be equal or superior to refractive multifocal IOLs with respect to contrast sensitivity [73–75]. Although contrast sensitivity in individuals with multifocal IOLs is diminished compared with individuals with monofocal IOLs, it is generally within the normal range of contrast in age-matched phakic individuals [39, 71]. Indeed, in a recent paper published by our research group, several IOL models including two trifocal IOLs (FineVision and AT LISA Tri 839 MP), two bifocals (Acri.Lisa 366D and Acrysof ReSTOR SN6D1), a refractive IOL (Lentis Mplus LS 313), and a monofocal IOL were compared in terms of low mesopic contrast sensitivity. The results showed that no differences were found among the multifocal IOLs studied; thus, the third focus of trifocal IOLs did not negatively affect the contrast sensitivity. The ReSTOR SN6D1 showed worse results that the monofocal IOL for the spatial frequency of 18 cpd [76].

Management In our opinion, the photic phenomena management starts before the cataract surgery with the multifocal IOL implantation is performed. The preoperative patient education is very important, and the patients should be told that they will notice glare and halos after the surgery (because they are inherent to the IOL design) although in most of the cases, the photic phenomena are mild to moderate, and most of the patients get used to it with time (neuroadaption process). However, we do not recommend to implant multifocal IOLs in night professional drivers, even more if the patient has a large scotopic pupil size which will increase the perception of halos and glare at night.

When the photic phenomena complaint is very prominent, all the causes that may exacerbate it (previously discussed in this chapter) have to be ruled out.

8.3.8 Dry Eye

Dry eye is a multifactorial disease of the tear film and the ocular surface that results in symptoms of discomfort, visual disturbance, and tear-film instability.

Dry eye and cataract formation are very common in the elderly population. In addition, cataract surgery can induce dry eye or exacerbate preexisting disease. The incisions created during surgery may damage the cornea's neuro-architecture, reduce corneal sensation, and induce dry eye disease[78]. A study found a significant increase in the incidence of dry eye in patients having cataract surgery [78]. In another study, patients with preexisting dry eye had decreased tear production and tear breakup time (TBUT) after cataract extraction, leading to ocular discomfort and irritation [79]. Given the inherent importance of the ocular surface and tear film to the quality of vision, dry eye may significantly degrade visual outcomes after multifocal IOL implantation [77].

Postoperative cataract surgery treatment may also play a role in triggering a dry eye or exacerbating a pre-existing one. Therefore, in our opinion, it is mandatory to use preservative-free drops and to avoid very long and unnecessary antibiotic prescriptions.

Management Dry eye treatment is not the purpose of this chapter, but as general guidelines we start the treatment by improving the eyelid hygiene and using artificial tears. In more resistant cases, the cyclosporine has proven to be a very useful treatment in improving patient symptoms and tear breakup time and decreasing conjunctival staining [77]. Another alternative to consider is to implant punctal plugs, especially in those patients with aqueous deficiency and lack of associated inflammation. We have a very positive experience with the use of PRP (platelet-rich plasma) drops in patients presenting with severe dry eye. We have conducted several studies which show that platelet-rich plasma has very good outcomes in treating dry eye, dry eye after LASIK surgery, corneal ulcer, and even perforated corneas in its solid form [80–84].

8.4 Multifocal IOL Explantation

As previously discussed, IOL explantation is the worst scenario possible after cataract surgery with multifocal IOL implantation because it may be associated with new complications and because it means that the aim of the original surgery is missed. Fortunately, it is only needed in very few patients of those who complain. Several studies show that the rate of multifocal IOL exchange among dissatisfied patients is 0.85% [10], 4% [8], and 7% [7].

In a study analyzing the main reasons for pseudophakic IOL explantation, the failure to neuroadapt in patients with multifocal lenses implanted was the fourth main cause of explantation after IOL dislocation (first cause), refractive error (second cause), and IOL opacification (third cause) [85]. Explantation surgery is always challenging; however, explantation of a multifocal lens is usually easier (especially with a capsular tension ring) than explantation due to the other causes: first, because the decision of explantation is made only few months after the cataract surgery, hence the scarring process has not occurred yet, and second because the ocular structures are undamaged; therefore, the surgery is less risky. In contrast, when performing IOL explantation due to other causes as dislocation or IOL opacification, the surgery is associated with more complications due to the ocular structures damage in the former and the presence of fibrotic tissue in the latter, especially, because in these cases the IOL explantation is performed long time after the original cataract surgery [86, 87].

The main issue about multifocal IOL explantation is if it is worth to do it. Did the satisfaction rate increased after the explantation surgery? Is it associated with a high complications incidence? Surprisingly, to date, there are only two papers [88, 89] answering these questions.

In the first publication, Galor et al. [88] retrospectively studied the outcomes after refractive IOL explantation in 12 eyes of 10 dissatisfied patients. In contrast to the paper title, the study comprised not only refractive IOLs: ReZoom (5 eyes), ReSTOR (4), Crystalens 4.5 (2), and Crystalens 5.0 (1). The main symptoms before surgery were blurry vision, glare/halos, and contrast sensitivity loss. The corrected and uncorrected distance visual acuity (CDVA and UDVA) was 20/30 or better in all the dissatisfied patients. The median time to IOL exchange after the initial cataract surgery was 13.6 months, and the median follow-up after the explantation surgery was 8.9 months. The surgical outcomes were the following: at 6 months UDVA was 20/30 or better in four eyes and 20/60 or better in eight eyes. Meanwhile, the CDVA at 6 months was 20/20 or better in eight eyes and 20/25 or better in nine eyes. Regarding the surgical complications, one eye had corneal decompensation, one eye had IOL dislocation needing another surgery to perform IOL sclera fixation, and one eye had steroid response with elevated IOP. The aim of the surgery was achieved in eight patients as they noticed an improvement of their symptoms, while the other two patients did not experience any change.

We can extract some conclusions from this paper. First, the symptoms leading to the explantation surgery were improved in most of the patients (8 of 10). Second, there was a refractive worsening after the exchange surgery: prior to the surgery all the eyes had UDVA of 20/30 or better, while in contrast, only four eyes achieved this result after the IOL exchange surgery. Third, in two eyes there were severe complications such as corneal decompensation and IOL dislocation requiring scleral suturing having steroid response with elevated IOP and cystoid macular edema in the postoperative course.

The other publication is a more recent and larger one. Kamiya et al. [89] show a retrospective study that included 50 eyes that required multifocal IOL explantation. Of the explanted multifocal IOLs, 84% were diffractive and 16% were refractive. Monofocal IOLs accounted for 90% of the new implanted IOLs. The most common complaints before the explantation surgery were waxy vision (58%), followed by glare and halos (30%), blurred vision at far (24%), dysphotopsia (20%), blurred vision at near (18%), and blurred vision at intermediate (6%).

The main objective reasons for explantation were decreased contrast sensitivity (36%), photic phenomena (34%), unknown origin including neuroadaption failure (32%), and incorrect lens power (20%).

Patient satisfaction for overall quality of vision was graded on a scale of 1 (very dissatisfied) to 5 (very satisfied). After the IOL exchange surgery, patient satisfaction was significantly increased from 1.22 ± 0.55 preoperatively to 3.78 ± 0.98.

The LogMAR mean preoperative UDVA and CDVA were 0.23 ± 0.27 and − 0.01 ± 0.16, respectively. Before the explantation surgery, 30% and 68% of the patients had a UDVA and CDVA of 20/20 or better, respectively. The visual outcomes after the explantation surgery showed that 42% and 86% of eyes achieved UDVA and CDVA of 20/20 or better.

Contrast sensitivity function also significantly improved after the IOL exchange surgery. The authors state that CDVA is not always a good measure of patient symptoms. In this study, despite visual complaints, CDVA was 20/20 or better in almost 70% of the eyes. Therefore, more specific tests, such as contrast sensitivity measurement, are needed especially in those cases with excellent CDVA.

Regarding complications, anterior vitrectomy was necessary in three cases (6%). The IOL was placed in the bag in 38 eyes (76%), out of the bag in the sulcus in 11 eyes (22%), and sulcus placement with scleral suture in 1 more eye (2%).

In conclusion, this paper shows that multifocal IOL explantation in dissatisfied patients is a feasible option that significantly improved patient satisfaction. It emphasizes the importance of performing specific tests for the accurate assessment of the visual function especially in patients with good visual acuity who complain of poor vision. Decreased contrast sensitivity was found in most of these cases.

However, it is important to keep in mind that IOL exchange is not exempt from complications. In this series, the IOL had to be placed in the ciliary sulcus in 24% of the cases, and anterior vitrectomy was performed in 6% of the eyes.

8.4.1 IOL Explantation Techniques

There are many explantation techniques described in the scientific literature [90–98]. In the recent years, the interest has been focused in explanting IOLs through small incisions (2.2–2.65 mm) in order to avoid astigmatism induction, thus improving the predictability associated with the exchange procedure.

The explantation techniques can be divided into four different types:

1. Whole lens removal. It is not currently used because wound enlargement is needed. It is only used in those nowadays marginal cases of rigid PMMA pseudophakic IOL. However, there is a publication about a surgical technique of explanting a single piece acrylic hydrophobic lens through a 2.75 mm incision without cutting or folding, just pulling the lens out with toothed forceps [99].
2. Intraocular lens cutting. Intraocular lens cuts are performed inside the eye in order to remove the lens through a small corneal incision. This can be done in many different ways: by bisecting the lens [90], partial bisection [91, 92], trisecting it [97], sectorial bisection [98], or by multiple cuts [96].
3. Intraocular lens haptic cutting. The haptics may be cut prior to the surgery with YAG laser [95] or at the time of the surgery with scissors [94], thus facilitating the removal of the optic. When the degree of fibrosis is so high that it is not possible to release the haptics without taking risks, it is preferable to leave the haptics in place.
4. Intraocular lens refolding. The IOL is folded in the anterior chamber and afterward explanted through a minimally enlarged incision [93]. However, this technique involves extensive manipulation and may cause more damage to clear corneal incisions and a 25% reduction in the endothelial cell count.

8.5 Summary

The implantation of multifocal intraocular lenses (MfIOLs) has a relevant importance in the last years as treatment of pseudophakic presbyopia [100]. After MfIOL implantation the vast majority of cases is happy and satisfied and does not need spectacles or contact lenses as visual aids after the operation. However, complications sometimes happen that influence the quality of life and the level of patient's satisfaction. The common symptoms of dissatisfaction with multifocal lenses are blurred vision and photic phenomena associated with residual ammetropia, posterior capsule opacification (PCO), large pupil size, wavefront anomalies, dry eye, and IOL decentration. The main reasons for pseudophakic IOL explantation are the failure to neuroadapt, IOL dislocation, residual refractive error, and IOL opacification. To avoid patient dissatisfaction after MfIOL implantation is important considering the following recommendations in the preoperative visit: the patient lifestyles, perform an exhaustive preoperative examination, study the biometry, topography, and pupil reactivity. It is very important to explain the patient the visual expectation and possible postoperative complications and solutions.

Compliance with ethical requirements: Jorge L. Alió and Roberto Fernández Buenaga declare that they have no conflict of interest. No human or animal studies were carried out by the authors for this article.

Reference List

1. Cillino G, Casuccio A, Pasti M, Bono V, Mencucci R, Cillino S. Working-age cataract patients: visual results, reading performance, and quality of life with three diffractive multifocal intraocular lenses. Ophthalmology. 2014;121:34–44.
2. Cillino S, Casuccio A, Di PF, et al. One-year outcomes with new-generation multifocal intraocular lenses. Ophthalmology. 2008;115:1508–16.
3. Kohnen T, Nuijts R, Levy P, Haefliger E, Alfonso JF. Visual function after bilateral implantation of apodized diffractive aspheric multifocal intraocular lenses with a +3.0 D addition. J Cataract Refract Surg. 2009;35:2062–9.
4. Alfonso JF, Fernandez-Vega L, Valcarcel B, Ferrer-Blasco T, Montes-Mico R. Outcomes and patient satisfaction after presbyopic bilateral lens exchange with the ResTOR IOL in emmetropic patients. J Refract Surg. 2010;26:927–33.
5. Alio JL, Plaza-Puche AB, Pinero DP, et al. Optical analysis, reading performance, and quality-of-life evaluation after implantation of a diffractive multifocal intraocular lens. J Cataract Refract Surg. 2011;37:27–37.
6. Mester U, Vaterrodt T, Goes F, et al. Impact of personality characteristics on patient satisfaction after multifocal intraocular lens implantation: results from the "happy patient study". J Refract Surg. 2014;30:674–8.
7. Woodward MA, Randleman JB, Stulting RD. Dissatisfaction after multifocal intraocular lens implantation. J Cataract Refract Surg. 2009;35:992–7.
8. de Vries NE, Webers CA, Touwslager WR, et al. Dissatisfaction after implantation of multifocal intraocular lenses. J Cataract Refract Surg. 2011;37:859–65.
9. Leyland M, Pringle E. Multifocal versus monofocal intraocular lenses after cataract extraction. Cochrane Database Syst Rev. 2006 Oct 18;(4):CD003169.
10. Venter JA, Pelouskova M, Collins BM, Schallhorn SC, Hannan SJ. Visual outcomes and patient satisfaction in 9366 eyes using a refractive segmented multifocal intraocular lens. J Cataract Refract Surg. 2013;39:1477–84.
11. Jung CK, Chung SK, Baek NH. Decentration and tilt: silicone multifocal versus acrylic soft intraocular lenses. J Cataract Refract Surg. 2000;26:582–5.
12. Kim JS, Shyn KH. Biometry of 3 types of intraocular lenses using Scheimpflug photography. J Cataract Refract Surg. 2001;27:533–6.
13. Nejima R, Miyata K, Honbou M, et al. A prospective, randomised comparison of single and three piece acrylic foldable intraocular lenses. Br J Ophthalmol. 2004;88:746–9.
14. Taketani F, Matuura T, Yukawa E, Hara Y. Influence of intraocular lens tilt and decentration on wavefront aberrations. J Cataract Refract Surg. 2004;30:2158–62.
15. Mutlu FM, Erdurman C, Sobaci G, Bayraktar MZ. Comparison of tilt and decentration of 1-piece and 3-piece hydrophobic acrylic intraocular lenses. J Cataract Refract Surg. 2005;31:343–7.
16. Taketani F, Yukawa E, Yoshii T, Sugie Y, Hara Y. Influence of intraocular lens optical design on high-order aberrations. J Cataract Refract Surg. 2005;31:969–72.
17. Baumeister M, Neidhardt B, Strobel J, Kohnen T. Tilt and decentration of three-piece foldable high-refractive silicone and hydrophobic acrylic intraocular lenses with 6-mm optics in an intraindividual comparison. Am J Ophthalmol. 2005;140:1051–8.
18. Tabernero J, Piers P, Benito A, Redondo M, Artal P. Predicting the optical performance of eyes implanted with IOLs to correct spherical aberration. Invest Ophthalmol Vis Sci. 2006;47:4651–8.
19. Rosales P, Marcos S. Phakometry and lens tilt and decentration using a custom-developed Purkinje imaging apparatus: validation and measurements. J Opt Soc Am A Opt Image Sci Vis. 2006;23:509–20.
20. De CA, Rosales P, Marcos S. Tilt and decentration of intraocular lenses in vivo from Purkinje and Scheimpflug imaging. Validation study. J Cataract Refract Surg. 2007;33:418–29.
21. Oshika T, Sugita G, Miyata K, et al. Influence of tilt and decentration of scleral-sutured intraocular lens on ocular higher-order wavefront aberration. Br J Ophthalmol. 2007;91:185–8.
22. Soda M, Yaguchi S. Effect of decentration on the optical performance in multifocal intraocular lenses. Ophthalmologica. 2012;227:197–204.
23. Hayashi K, Hayashi H, Nakao F, Hayashi F. Correlation between pupillary size and intraocular lens decentration and visual acuity of a zonal-progressive multifocal lens and a monofocal lens. Ophthalmology. 2001;108:2011–7.
24. Eppig T, Scholz K, Loffler A, Messner A, Langenbucher A. Effect of decentration and tilt on the image quality of aspheric intraocular lens designs in a model eye. J Cataract Refract Surg. 2009;35:1091–100.
25. Park CY, Oh SY, Chuck RS. Measurement of angle kappa and centration in refractive surgery. Curr Opin Ophthalmol. 2012;23:269–75.

26. Prakash G, Prakash DR, Agarwal A, Kumar DA, Agarwal A, Jacob S. Predictive factor and kappa angle analysis for visual satisfactions in patients with multifocal IOL implantation. Eye (Lond). 2011 Sep;25(9):1187–93.
27. Karhanová M, Marešová K, Pluháček F, Mlčák P, Vláčil O, Sín M. The importance of angle kappa for centration of multifocal intraocular lenses. Cesk Slov Oftalmol. 2013;69(2):64–8.
28. Crnej A, Hirnschall N, Nishi Y, et al. Impact of intraocular lens haptic design and orientation on decentration and tilt. J Cataract Refract Surg. 2011;37:1768–74.
29. Qatarneh D, Hau S, Tuft S. Hyperopic shift from posterior migration of hydrophilic acrylic intraocular lens optic. J Cataract Refract Surg. 2010;36:161–3.
30. van der Linden JW, van der Meulen IJ, Mourits MP, Lapid-Gortzak R. In-the-bag decentration of a hydrophilic radially asymmetric multifocal intraocular lens secondary to capsule contraction. J Cataract Refract Surg. 2013;39:642–4.
31. Alio JL, Pinero DP, Plaza-Puche AB, Chan MJ. Visual outcomes and optical performance of a monofocal intraocular lens and a new-generation multifocal intraocular lens. J Cataract Refract Surg. 2011;37:241–50.
32. Alio JL, Plaza-Puche AB, Javaloy J, Ayala MJ, Vega-Estrada A. Clinical and optical intraocular performance of rotationally asymmetric multifocal IOL plate-haptic design versus C-loop haptic design. J Refract Surg. 2013;29:252–9.
33. Alio JL, Plaza-Puche AB, Pinero DP. Rotationally asymmetric multifocal IOL implantation with and without capsular tension ring: refractive and visual outcomes and intraocular optical performance. J Refract Surg. 2012;28:253–8.
34. Kim JH, Kim H, Joo CK. The effect of capsular tension ring on posterior capsular opacity in cataract surgery. Korean J Ophthalmol. 2005;19:23–8.
35. Lee DH, Lee HY, Lee KH, Chung KH, Joo CK. Effect of a capsular tension ring on the shape of the capsular bag and opening and the intraocular lens. J Cataract Refract Surg. 2001;27:452–6.
36. Lee DH, Shin SC, Joo CK. Effect of a capsular tension ring on intraocular lens decentration and tilting after cataract surgery. J Cataract Refract Surg. 2002;28:843–6.
37. Rohart C, Gatinel D. Influence of a capsular tension ring on ocular aberrations after cataract surgery: a comparative study. J Refract Surg. 2009;25:S116–21.
38. Sun R. Functions of the capsular tension ring. J Cataract Refract Surg. 2007;33:4.
39. Montes-Mico R, Espana E, Bueno I, Charman WN, Menezo JL. Visual performance with multifocal intraocular lenses: mesopic contrast sensitivity under distance and near conditions. Ophthalmology. 2004;111:85–96.
40. Choi J, Schwiegerling J. Optical performance measurement and night driving simulation of ReSTOR, ReZoom, and Tecnis multifocal intraocular lenses in a model eye. J Refract Surg. 2008;24:218–22.
41. Artigas JM, Menezo JL, Peris C, Felipe A, Diaz-Llopis M. Image quality with multifocal intraocular lenses and the effect of pupil size: comparison of refractive and hybrid refractive-diffractive designs. J Cataract Refract Surg. 2007;33:2111–7.
42. Behndig A, Montan P, Stenevi U, Kugelberg M, Zetterstrom C, Lundstrom M. Aiming for emmetropia after cataract surgery: Swedish National Cataract Register study. J Cataract Refract Surg. 2012;38:1181–6.
43. Snead MP, Rubinstein MP, Lea SH, Haworth SM. Calculated versus A-scan result for axial length using different types of ultrasound probe tip. Eye (Lond). 1990;4(Pt 5):718–22.
44. Pierro L, Modorati G, Brancato R. Clinical variability in keratometry, ultrasound biometry measurements, and emmetropic intraocular lens power calculation. J Cataract Refract Surg. 1991;17:91–4.
45. Raman S, Redmond R. Reasons for secondary surgical intervention after phacoemulsification with posterior chamber lens implantation. J Cataract Refract Surg. 2003;29:513–7.
46. Erickson P. Effects of intraocular lens position errors on postoperative refractive error. J Cataract Refract Surg. 1990;16:305–11.
47. Alfonso JF, Fernandez-Vega L, Montes-Mico R, Valcarcel B. Femtosecond laser for residual refractive error correction after refractive lens exchange with multifocal intraocular lens implantation. Am J Ophthalmol. 2008;146:244–50.
48. Leccisotti A. Secondary procedures after presbyopic lens exchange. J Cataract Refract Surg. 2004;30:1461–5.
49. Pop M, Payette Y, Amyot M. Clear lens extraction with intraocular lens followed by photorefractive keratectomy or laser in situ keratomileusis. Ophthalmology. 2001;108:104–11.
50. Ayala MJ, Perez-Santonja JJ, Artola A, Claramonte P, Alio JL. Laser in situ keratomileusis to correct residual myopia after cataract surgery. J Refract Surg. 2001;17:12–6.
51. Norouzi H, Rahmati-Kamel M. Laser in situ keratomileusis for correction of induced astigmatism from cataract surgery. J Refract Surg. 2003;19:416–24.
52. Muftuoglu O, Prasher P, Chu C, et al. Laser in situ keratomileusis for residual refractive errors after apodized diffractive multifocal intraocular lens implantation. J Cataract Refract Surg. 2009;35:1063–71.
53. Pinero DP, Espinosa MJ, Alio JL. LASIK outcomes following multifocal and monofocal intraocular Lens implantation. J Refract Surg. 2010 Aug;26(8):569–77.
54. Habot-Wilner Z, Sachs D, Cahane M, et al. Refractive results with secondary piggyback implantation to correct pseudophakic refractive errors. J Cataract Refract Surg. 2005;31:2101–3.
55. Jin GJ, Crandall AS, Jones JJ. Intraocular lens exchange due to incorrect lens power. Ophthalmology. 2007;114:417–24.

56. Fernandez-Buenaga R, Alio JL, Perez Ardoy AL, Quesada AL, Pinilla CL, Barraquer RI. Resolving refractive error after cataract surgery: IOL exchange, piggyback lens, or LASIK. J Refract Surg. 2013;29:676–83.
57. Jendritza BB, Knorz MC, Morton S. Wavefront-guided excimer laser vision correction after multifocal IOL implantation. J Refract Surg. 2008;24:274–9.
58. Spalton DJ. Posterior capsular opacification after cataract surgery. Eye (Lond). 1999;13. (Pt 3b:489–92.
59. Allen D, Vasavada A. Cataract and surgery for cataract. BMJ. 2006;333:128–32.
60. Awasthi N, Guo S, Wagner BJ. Posterior capsular opacification: a problem reduced but not yet eradicated. Arch Ophthalmol. 2009;127:555–62.
61. Javitt JC, Tielsch JM, Canner JK, Kolb MM, Sommer A, Steinberg EP. National outcomes of cataract extraction. Increased risk of retinal complications associated with Nd:YAG laser capsulotomy. The cataract patient outcomes research team. Ophthalmology. 1992;99:1487–97.
62. Findl O, Buehl W, Bauer P, Sycha T. Interventions for preventing posterior capsule opacification. Cochrane Database Syst Rev. 2010 Feb 17;(2):CD003738.
63. Shah VC, Russo C, Cannon R, Davidson R, Taravella MJ. Incidence of Nd:YAG Capsulotomy after implantation of AcrySof multifocal and Monofocal intraocular lenses: a case controlled study. J Refract Surg. 2010 Aug;26(8):565–8.
64. Gauthier L, Lafuma A, Laurendeau C, Berdeaux G. Neodymium:YAG laser rates after bilateral implantation of hydrophobic or hydrophilic multifocal intraocular lenses: twenty-four month retrospective comparative study. J Cataract Refract Surg. 2010;36:1195–200.
65. Bilbao-Calabuig R, Llovet-Osuna F, González-López F, Beltrán J. Nd:YAG Capsulotomy rates with two trifocal intraocular lenses. J Refract Surg. 2016;32(11):748–52.
66. de Vries NE, Nuijts RM. Multifocal intraocular lenses in cataract surgery: literature review of benefits and side effects. J Cataract Refract Surg. 2013;39:268–78.
67. Chiam PJ, Chan JH, Aggarwal RK, Kasaby S. ReSTOR intraocular lens implantation in cataract surgery: quality of vision. J Cataract Refract Surg. 2006;32:1459–63.
68. Haring G, Dick HB, Krummenauer F, Weissmantel U, Kroncke W. Subjective photic phenomena with refractive multifocal and monofocal intraocular lenses. results of a multicenter questionnaire. J Cataract Refract Surg. 2001;27:245–9.
69. Brito P, Salgado-Borges J, Neves H, et al. Light-distortion analysis as a possible indicator of visual quality after refractive lens exchange with diffractive multifocal intraocular lenses. J Cataract Refract Surg. 2015;41:613–22.
70. Alió JL, Plaza-Puche AB, Alió Del Barrio JL, Amat-Peral P, Ortuño V, Yébana P, Al-Shymali O, Vega-Estrada A. Clinical outcomes with a diffractive trifocal intraocular lens. Eur J Ophthalmol. 2018;28(4):419–24.
71. Alfonso JF, Puchades C, Fernandez-Vega L, Merayo C, Montes-Mico R. Contrast sensitivity comparison between AcrySof ReSTOR and Acri.LISA aspheric intraocular lenses. J Refract Surg. 2010;26:471–7.
72. Aychoua N, Junoy Montolio FG, Jansonius NM. Influence of multifocal intraocular lenses on standard automated perimetry test results. JAMA Ophthalmol. 2013;131:481–5.
73. Mesci C, Erbil HH, Olgun A, Aydin N, Candemir B, Akcakaya AA. Differences in contrast sensitivity between monofocal, multifocal and accommodating intraocular lenses: long-term results. Clin Exp Ophthalmol. 2010;38:768–77.
74. Mesci C, Erbil H, Ozdoker L, Karakurt Y, Bilge AD. Visual acuity and contrast sensitivity function after accommodative and multifocal intraocular lens implantation. Eur J Ophthalmol. 2010;20: 90–100.
75. Mester U, Hunold W, Wesendahl T, Kaymak H. Functional outcomes after implantation of Tecnis ZM900 and Array SA40 multifocal intraocular lenses. J Cataract Refract Surg. 2007;33:1033–40.
76. Plaza-Puche AB, Alio JL, Sala E, Mojzis P. Impact of low mesopic contrast sensitivity outcomes in different types of modern multifocal intraocular lenses. Eur J Ophthalmol. 2016;26(6):612–7.
77. Donnenfeld ED, Solomon R, Roberts CW, Wittpenn JR, McDonald MB, Perry HD. Cyclosporine 0.05% to improve visual outcomes after multifocal intraocular lens implantation. J Cataract Refract Surg. 2010;36:1095–100.
78. Li XM, Hu L, Hu J, Wang W. Investigation of dry eye disease and analysis of the pathogenic factors in patients after cataract surgery. Cornea. 2007;26:S16–20.
79. Ram J, Gupta A, Brar G, Kaushik S, Gupta A. Outcomes of phacoemulsification in patients with dry eye. J Cataract Refract Surg. 2002;28:1386–9.
80. Alio JL, Colecha JR, Pastor S, Rodriguez A, Artola A. Symptomatic dry eye treatment with autologous platelet-rich plasma. Ophthalmic Res. 2007;39:124–9.
81. Alio JL, Pastor S, Ruiz-Colecha J, Rodriguez A, Artola A. Treatment of ocular surface syndrome after LASIK with autologous platelet-rich plasma. J Refract Surg. 2007;23:617–9.
82. Javaloy J, Alio JL, Rodriguez AE, Vega A, Munoz G. Effect of platelet-rich plasma in nerve regeneration after LASIK. J Refract Surg. 2013;29:213–9.
83. Alio JL, Arnalich-Montiel F, Rodriguez AE. The role of "eye platelet rich plasma" (E-PRP) for wound healing in ophthalmology. Curr Pharm Biotechnol. 2012;13:1257–65.
84. Alio JL, Rodriguez AE, Martinez LM, Rio AL. Autologous fibrin membrane combined with solid platelet-rich plasma in the management of perforated corneal ulcers: a pilot study. JAMA Ophthalmol. 2013;131:745–51.

85. Fernandez-Buenaga R, Alio JL, Munoz-Negrete FJ, Barraquer Compte RI, Alio-Del Barrio JL. Causes of IOL explantation in Spain. Eur J Ophthalmol. 2012;22:762–8.
86. Fernandez-Buenaga R, Alio JL, Perez-Ardoy AL, et al. Late in-the-bag intraocular lens dislocation requiring explantation: risk factors and outcomes. Eye (Lond). 2013;27:795–801.
87. Fernandez-Buenaga R, Alio JL, Pinilla-Cortes L, Barraquer RI. Perioperative complications and clinical outcomes of intraocular lens exchange in patients with opacified lenses. Graefes Arch Clin Exp Ophthalmol. 2013;251:2141–6.
88. Galor A, Gonzalez M, Goldman D, O'Brien TP. Intraocular lens exchange surgery in dissatisfied patients with refractive intraocular lenses. J Cataract Refract Surg. 2009;35:1706–10.
89. Kamiya K, Hayashi K, Shimizu K, Negishi K, Sato M, Bissen-Miyajima H. Multifocal intraocular lens explantation: a case series of 50 eyes. Am J Ophthalmol. 2014;158:215–20.
90. Koo EY, Lindsey PS, Soukiasian SH. Bisecting a foldable acrylic intraocular lens for explantation. J Cataract Refract Surg. 1996;22(Suppl 2):1381–2.
91. Batlan SJ, Dodick JM. Explantation of a foldable silicone intraocular lens. Am J Ophthalmol. 1996;122:270–2.
92. Mehta JS, Wilkins MR, Gartry DS. Explantation of an acrylic Acrysof intraocular lens without wound enlargement. Acta Ophthalmol Scand. 2005;83:262–3.
93. Neuhann TH. Intraocular folding of an acrylic lens for explantation through a small incision cataract wound. J Cataract Refract Surg. 1996;22(Suppl 2):1383–6.
94. Geggel HS. Simplified technique for acrylic intraocular lens explantation. Ophthalmic Surg Lasers. 2000;31:506–7.
95. Marques FF, Marques DM, Smith CM, Osher RH. Intraocular lens exchange assisted by preoperative neodymium:YAG laser haptic fracture. J Cataract Refract Surg. 2004;30:247–9.
96. Osher RH. Crisscross lensotomy: new explantation technique. J Cataract Refract Surg. 2006;32:386–8.
97. Por YM, Chee SP. Trisection technique: a 2-snip approach to intraocular lens explantation. J Cataract Refract Surg. 2007;33:1151–4.
98. Karamaounas N, Kourkoutas D, Prekates C. Surgical technique for small-incision intraocular lens exchange. J Cataract Refract Surg. 2009;35:1146–9.
99. Henderson BA, Yang EB. Intraocular lens explantation technique for one-piece acrylic lenses. J Refract Surg. 2012;28:499–502.
100. Alió JL, Plaza-Puche AB, Fernandez-Buenaga R, Pikkel J, Maldonado M. Multifocal intraocular lenses: an overview on the technology, indications, outcomes, complications and their management. Surv Ophthalmol. 2017;62(5):611–34.