Comparison of outcomes with multifocal intraocular lenses: a meta-analysis

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Purpose: To compare the clinical outcome of different multifocal intraocular lenses (IOLs) based on information reported in the international literature.

Methods: All comparative clinical trials that involved implanting at least one multifocal IOL in patients with cataract or presbyopia were extracted from the literature. Clinical outcomes included uncorrected near visual acuity, uncorrected distance visual acuity, visual acuity, spectacle independence, and halos. Random effects meta-analyses were conducted to compare outcomes for the different IOL types.

Results: Twenty papers were identified describing 11 monofocal IOLs and 35 multifocal IOLs (19 diffractive, including 12 ReSTOR®, 14 refractive, and two accommodative) patient cohorts. Multifocal and monofocal uncorrected distance visual acuity was 0.165 (0.090–0.240) and 0.093 (0.088–0.098), respectively. Compared with monofocal IOLs, multifocal IOLs produced better uncorrected near visual acuity (0.470 [0.322–0.618] versus 0.141 [0.131–0.152]; P < 0.0001), resulting in higher spectacle independence (incidence rate ratio [IRR] 3.62 [2.90–4.52]; P < 0.0001). Compared with refractive multifocal IOLs, diffractive multifocal IOLs produced a similar uncorrected distance visual acuity (0.105 [0.098–0.111] versus 0.085 [0.029–0.140]; P ≤ 0.78, not significant) and better uncorrected near visual acuity (0.217 [0.118–0.317] versus 0.082 [0.067–0.098]; P < 0.0001) resulting in higher spectacle independence (IRR 1.75 [1.24–2.48]; P < 0.001). Compared with other multifocal IOLs, ReSTOR produced a better uncorrected distance visual acuity (0.067 [0.059–0.076] versus 0.093 [0.088–0.098]; P < 0.0001) and better uncorrected near visual acuity (0.064 [0.046–0.082] versus 0.141 [0.131–0.152]; P < 0.006), resulting in higher spectacle independence (IRR 2.06 [1.26–1.36]; P < 0.004). Halo incidence rates with different types of multifocal implants did not differ significantly.

Conclusion: Multifocal IOLs provide better uncorrected near visual acuity than monofocal IOLs, leading to less need for spectacles. Multifocal IOL design might play a role in postsurgical outcome, because better results were obtained with diffractive lenses. ReSTOR showed better uncorrected near visual acuity, uncorrected distance visual acuity, and higher spectacle independence rates compared with other multifocal IOLs.

Keywords: multifocal implants, meta-analysis, uncorrected near visual acuity, uncorrected distance visual acuity, spectacle independence, patient satisfaction

Introduction
An estimated 20.5 million Americans older than 40 years have cataract in at least one eye.¹ While cataract is the leading cause of blindness worldwide,²³ most populations in developed Western countries have access to cataract surgery (eg, 6.1 million [5.1%] of American citizens have pseudophakia/aphakia). The total number of Americans with cataract is predicted to increase to 30.1 million by 2020, of whom 9.5 million are expected to...
have pseudophakia. More than 80% of patients regain good best-corrected visual acuity (visual acuity ≥ 8/10) after cataract surgery, depending on other ocular pathology and duration of follow-up.4,8

Traditional intraocular lenses (IOLs) are monofocal, and after implantation most patients need spectacles, at least for near vision. Multifocal IOLs are intended to free patients from spectacles after presbyopia or cataract surgery by applying the principle of simultaneous vision.9 Early multifocal IOLs were associated with loss of clarity and poor accommodation, reduced contrast sensitivity, and complaints of halos and glare. Improvements in intraocular lens technology have enabled cataract patients to be implanted with multifocal IOLs to provide better visual acuity at various distances and a degree of spectacle independence.10

Today, multifocal IOLs produce functional near and distance vision and acceptable levels of patient satisfaction in everyday practice.11–14 However, reviews on the clinical consequences of multifocal implantations are rare.15

Many IOL clinical trials have been performed, but to our knowledge, no relevant meta-analysis has been reported. Our objective was to conduct a meta-analysis of published comparative clinical trials in which at least one patient group was implanted with multifocal implants bilaterally.

Materials and methods

Bibliographic research
An extensive literature review was performed through Medline and most recently updated on June 30, 2009. The following multifocal IOL names were used as keywords: Acrilisa® (Carl Zeiss Meditec, La Rochelle, France), Diffractiva® (HumanOptics, Erlangen, Germany), Rayner® (Rayner Intraocular Lenses Ltd., Hove, UK), ReSTOR® (Alcon Inc., Fort Worth, TX), Rezoom® (Abbott Medical Optics, Santa Ana, CA), and Tecnis® (Abbott Medical Optics), together with keywords focusing on comparative clinical trials, ie, “cataract surgery”, “comparison”, “multifocal”, and “visual acuity”. Abstracts were scrutinized and full articles ordered and analyzed in depth if they reported comparative studies in adult patients.

Inclusion criteria were publication in the French or English language, bilateral implantation of the same IOL, use of Tecnis, Acrilisa, Rezoom, Diffractiva, Rayner, or ReSTOR implants, and publication from 2000 onwards.

Exclusion criteria included comparison of different populations, double implantation in the same eye, double reporting, exploitation of the implant, in vitro studies, no aggregated results, noncomparative studies, unilateral implantation, and use of a refractive procedure (eg, Lasik).

All available data from the selected articles were extracted and tabulated with respect to each study’s identity, its design (prospective or retrospective, randomized or not randomized), IOL names and type (monofocal or multifocal; diffractive or refractive), reasons for IOL implantation, number of patients at baseline and at final follow-up, average follow-up duration, final overall patient satisfaction, spectacle dependency, uncorrected distance visual acuity, uncorrected intermediate visual acuity, uncorrected near visual acuity, and the number of patients reporting “halos”.

Data analysis
Outcome variables of the study were as follows:

- Uncorrected distance and near visual acuities converted to LogMAR equivalents, as described in detail elsewhere, when expressed in a different unit.
- Freedom from spectacles (independence), separately analyzed for distance and reading spectacles. It should be noted, however, that most studies combined all types of spectacles to express an overall need for spectacles, instead of providing specific information on distance versus reading spectacles.
- Patient satisfaction; given that variations between studies existed, to assess patient satisfaction, we standardized measurements according to the range of the measurements reported in each study.
- Presence of halo, which was reported using various definitions among the studies. Prevalence (presence versus absence of halos) was reported in this study.

We compared the aforementioned outcomes for the following subgroups of IOL implants: monofocal versus multifocal implants; diffractive versus refractive multifocal implants (data were insufficient to assess the effects of accommodative implants separately); and ReSTOR versus other multifocal implants. ReSTOR outcomes were highlighted because they relate to a new type of multifocal apodized IOL.

Statistical analysis
We used random effects models to obtain pooled estimates of visual acuity with 95% confidence intervals (CI), and tested for statistically significant differences between the estimates with respect to each IOL subgroup.

We used random effects Poisson regression models to compare the effect of IOL implant type on the need for spectacles. The outcome of interest was the number of patients needing spectacles, with study effects taken into account by the random effects component of the models. The exposure
variable for the Poisson models was defined as the product of the number of patients receiving a given implant and the average period of follow-up for each study. Similarly, we used random effects Poisson regression models to compare overall patient satisfaction and the presence of halo across subgroups of implants.

Forest plots were used to present the results. The lines represent the estimates from different studies and their CI. The boxes represent graphically the weight given to each study in calculating the pooled estimate for a given outcome. This weight is essentially a function of the number of patients followed up in different studies.

**Results**

**Bibliographic research**

Initial electronic searches identified 197 titles or abstracts. Complete copies of all possibly relevant papers were obtained, according to the criteria specified earlier. Fifty-one papers appeared to meet the inclusion criteria for this review.

Twenty of the 51 studies were included in the meta-analysis. The excluded 31 papers finally did not meet the inclusion and exclusion criteria. Reasons for exclusion were, as follows: a different IOL in each eye (n = 19); no comparison IOL (n = 6); double reporting (n = 4); comparison of different populations (n = 4); comparisons of multifocal IOLs (n = 2); either no data or aggregated data (n = 8); results after Lasik or another procedure (n = 2); and in vitro results (n = 1).

**Descriptive data analysis**

Twenty studies were included in the meta-analysis, of which 16 were prospective studies (80%) and four were retrospective (Table 1). Eight (50%) of the prospective studies were randomized. Data were collected from 46 patient groups, comprising 35 multifocal implant groups (76.1%) and 11 monofocal implant groups (23.9%). Among the multifocal implant groups, 19 were implanted with diffractive IOLs, 14 with refractive IOLs, and two with accommodative IOLs. ReSTOR was implanted in 12 of these groups (34.3%). Accommodative implants were studied in 26 patients only, and so were not analyzed as a specific group. Uncorrected distance vision acuity was described for 30 groups and near vision acuity for 23 groups.

All except six publications reported patient satisfaction as percentages of patients “satisfied” or “very satisfied”. Four papers isolated “patient satisfaction with vision” from a broader assessment of “overall satisfaction”. One paper rated satisfaction on a scale from 0 to 10 (maximal satisfaction). Finally, one paper used a questionnaire yielding a global measure of overall satisfaction that included a validated “VF-14 index of visual function”.

Fourteen (70%) of the 20 publications assessed spectacle independence, expressed in most cases as the number, or percentage, of patients who at the end of the follow-up period needed spectacles for reading or distance vision. Other studies asked patients how often they wore spectacles and gave them the response options of “always”, “occasionally”, or “never”. Distance vision (spectacle independence) was not stated by 10 studies, and only four studies gave both distance and near vision, by indicating patients requiring the respective correction spectacles. Visual disturbances, which could be night-time halos, moderate halos, or severe halos, were reported by 10 studies (50%). Table 2 summarizes the characteristics of all 20 publications included in this meta-analysis and provides references to them.

**Visual acuity**

Table 3 shows pooled estimates of random effects, with 95% CI, for uncorrected distance and near visual acuity (LogMAR scale) after multifocal and multifocal IOL implants. Separate estimates are shown for diffractive and refractive multifocal implants and for ReSTOR.

Table 4 shows that multifocal and monofocal uncorrected distance visual acuity was 0.165 and 0.093, respectively. Between the multifocal implants, there was no statistically significant uncorrected distance visual acuity difference (P = 0.78), or between diffractive IOLs (average LogMAR 0.105) and refractive IOLs (average LogMAR 0.085). However, uncorrected distance visual acuity was significantly better with ReSTOR (average LogMAR 0.067) as compared with other multifocal implants (P < 0.001). Table 4 also shows that uncorrected near visual acuity was significantly better (P < 0.001) after multifocal implants (average LogMAR 0.141) than monofocal IOLs (average LogMAR 0.470). Moreover, with multifocal implants, uncorrected near visual acuity was significantly better (P = 0.002) with diffractive IOLs (average LogMAR 0.082) than refractive IOLs (average LogMAR 0.217). Furthermore, uncorrected near visual acuity was significantly better (P = 0.006) after ReSTOR implants (average LogMAR 0.064) than after all other multifocal IOLs. Forest plots of uncorrected near and distance visual acuity are reported in Figures 1–4.

**Freedom from spectacles**

Table 5 shows the results of random effects Poisson regression models comparing the incidence of no spectacle require-
ment after different IOL implants. In general, patients with multifocal IOL implants, especially those with diffractive implants, were most likely not to need spectacles. Estimates varied for near and distance vision spectacles, compared with all spectacles combined, with most estimates specific to the two spectacle types not reaching statistical significance, probably because too few specific data were available for analysis. Overall, however, patients with multifocal implants were 3.6 times more likely not to need spectacles (incidence rate ratio [IRR] 3.62, 95% CI: 2.90–4.52).

Diffractive IOL implants were associated with a 1.75-times higher likelihood of spectacle independence (IRR 1.75, 95% CI: 1.24–2.48) than refractive implants. Also, patients implanted with ReSTOR had a more than two-fold higher incidence of spectacle independence compared with other multifocal IOLs (IRR 2.06, 95% CI: 1.26–3.36).

Table 1 Characteristics, references, and available results of the published studies

| Reference                  | Design | IOL                  | Trt | Satisfaction                                                   | Spectacle classification   | Halo |
|----------------------------|--------|----------------------|-----|---------------------------------------------------------------|----------------------------|------|
| Bi et al19                 | P      | ReSTOR vs Acrysof    | N   | Satisfaction with reading acuity                             | Spectacle independence     | N    |
| Chiam et al20              | P      | ReSTOR vs Rezoom     | Y   | Overall satisfaction                                          | Spectacle independence     | Y    |
| Toto et al21               | P      | ReSTOR vs Tecnis     | Y   | Overall satisfaction                                          | Spectacle independence     | N    |
| Souza et al22              | P      | ReSTOR vs Acrysof    | N   | % of patients completely or very satisfied                  | Spectacle independence     | Y    |
| Vingolo et al23            | R      | ReSTOR vs Acrysof    | n.m.| % of patients completely or very satisfied                  | Spectacle independence     | Y    |
| Alfonso et al24            | P      | ReSTOR SA60D3 vs ReSTOR SN60D3 | N   | Overall satisfaction                                          | Near distance spectacle independence | N    |
| Chiam et al25              | P      | ReSTOR vs Acrysof    | n.m.| Overall satisfaction                                         | Spectacle independence     | Y    |
| Pepose et al26             | P      | ReSTOR vs Rezoom vs Crystalaens | N   | Overall satisfaction                                         | Near and distance spectacle independence | N    |
| Mester et al27             | P      | Tecnis vs Array      | Y   | % of patients completely or very satisfied                  | Spectacle independence     | Y    |
| Brydon et al28             | R      | Array vs SI-30NB     | N   | % of patients satisfied with results                          | Spectacle independence     | N    |
| Chen et al29               | R      | Monofocal Acrysof vs Array | N   | % of patients completely or very satisfied                  | Spectacle independence     | N    |
| Sen et al30                | P      | Array vs SI-40NB     | Y   | % of patients completely or very satisfied                  | Spectacle independence     | Y    |
| Javitt et al31             | P      | Array vs AMO         | Y   | % of patients completely or very satisfied                  | Spectacle independence     | N    |
| Cochener et al32           | P      | ReSTOR vs Acrysof MA60BM | N   | % of patients completely or very satisfied                  | Spectacle independence     | Y    |
| Alio et al33               | P      | Crystalaens (AT45) vs Array SA40N vs Acritec twinset | N   | % of patients completely or very satisfied                  | Spectacle independence     | Y    |
| Cillino36                  | P      | AR40 (AMO) vs Array SA40N vs Rezoom (AMO) vs Tecnis ZM900 | Y   | Overall satisfaction                                         | Full spectacle independence | Y    |
| Zelichowska et al35        | R      | ReSTOR SN60D3 vs Rezoom | n.m.| % of patients completely or very satisfied                  | Spectacle independence     | N    |
| Barisic et al34            | P      | Tecnis multifocal vs Rezoom | Y   | % of patients completely or very satisfied                  | Spectacle independence     | N    |
| Chang-David35              | P      | ReSTOR vs Rezoom     | N   | % of patients completely or very satisfied                  | Spectacle independence     | Y    |
| Martinez-Palmer et al36    | P      | Tecnis Z9000 vs Tecnis ZM900 vs Rezoom vs Acritec twinset | Y   | % of patients completely or very satisfied                  | Spectacle independence     | N    |

Abbreviations: n.m., not mentioned; P, prospective; R, retrospective; Trt, treatment affected at random; vs, versus; Y, yes; N, no; IOL, intraocular lens implant.
Table 2 Characteristics of the implants included in the 20 articles

| #   | Reference          | IOL             | Type  | MIOL type     | Follow-up (weeks) | Patients (n) |
|-----|--------------------|------------------|-------|---------------|-------------------|--------------|
| 3   | Bi et al[19]       | ReSTOR Acrysof   | MIOL  | Diffractive   | 12                | 20           |
|     | SN60AT             |                  | Mono  |               | 12                | 18           |
| 5   | Chiam et al[20]    | ReSTOR ResZoom   | MIOL  | Diffractive   | 24                | 50           |
|     |                    | MIOL refractive  |       |               | 24                | 50           |
| 8   | Toto et al[21]     | ReSTOR Tecnis ZM900 | MIOL  | Diffractive   | 24                | 14           |
|     | MiOL Diffractive   |                  |       |               | 24                | 14           |
| 9   | Souza et al[22]    | ReSTOR Acrysof   | MIOL  | Diffractive   | 16                | 24           |
|     | SA60AT             |                  | Mono  |               | 16                | 15           |
| 10  | Vingolo et al[23]  | ReSTOR Acrysof   | MIOL  | Diffractive   | 24                | 50           |
|     | SA60D3             |                  | Mono  |               | 24                | 20           |
| 11  | Alfonso et al[24]  | ReSTOR Acrysof   | MIOL  | Diffractive   | 24                | 325          |
|     | SA60D3             |                  | Mono  |               | 24                | 335          |
| 19  | Blaylock[41]       | ReSTOR Acrysof   | MIOL  | Diffractive   | 8                 | 40           |
|     | SN60D3             |                  | Mono  |               | 8                 | 40           |
| 25  | Pepose et al[24]   | ReSTOR Acrysof   | MIOL  | Diffractive   | 20                | 12           |
|     | ReZoom Acrysof     |                  | Mono  |               | 20                | 14           |
|     | Crystalens AT45    | MIOL Accommodative |       |               | 20                | 14           |
| 32  | Mester et al[27]   | Tecnis ZM900     | MIOL  | Diffractive   | 24                | 23           |
|     | Array SA40         | MIOL Refractive  |       |               | 24                | 24           |
| 36  | Brydon et al[28]   | Array SI30NB     | MIOL  | Refractive    | 12                | 15           |
|     | Si30NB             |                  | Mono  |               | 12                | 13           |
| 38  | Chen et al[29]     | Array Sn60D3     | MIOL  | Diffractive   | 8                 | 40           |
|     | Acrysof            |                  | Mono  |               | 8                 | 40           |
| 41  | Sen et al[30]      | Array Sn60D3     | MIOL  | Refractive    | 4                 | 35           |
|     | Array SI40NB       |                  | Mono  |               | 4                 | 40           |
| 43  | Javitt et al[31]   | Array SI40NB     | MIOL  | Refractive    | 12                | 123          |
|     | PhacoFlex SI40NB   |                  | Mono  |               | 12                | 109          |
| 53  | Cochener et al[32] | ReSTOR Acrysof   | MIOL  | Diffractive   | 21                | 499          |
|     | MA60BM             |                  | Mono  |               | 21                | 173          |
| 55  | Alio et al[27]     | Acrysof          | MIOL  | Accommodative | 48                | 48           |
|     | MA60BM             |                  | Mono  |               | 48                | 16           |
| 56  | Cillino et al[16]  | AR40 (AMO)       | MIOL  | Diffractive   | 48                | 15           |
|     | Array SA40N        | MIOL Refractive  |       |               | 48                | 16           |
|     | Acritec twinset    | MIOL Diffractive |       |               | 48                | 12           |
| 57  | Zelichowska et al[33] | ReSTOR MIOL   | Diffractive | 48                | 16           |
|     | SN60D3             |                  | Mono  |               | 48                | 48           |
| 59  | Barisic et al[34]  | ReSTOR ReZoom    | MIOL  | Diffractive   | 24                | 23           |
|     | Tecnis multifocal  |                  | Mono  |               | 24                | 23           |
| 60  | Chang-David[35]    | ReSTOR ReZoom    | MIOL  | Diffractive   | 24                | 14           |
|     | ReZoom             |                  | Mono  |               | 24                | 14           |
| 61  | Martinez-Palmer et al[32] | ReSTOR MIOL  | Diffractive | 12                | 24           |
|     | Tecnis Z9000       |                  | Mono  |               | 12                | 24           |
|     | Tecnis ZM900       | MIOL Diffractive |       |               | 12                | 26           |
|     | ReZoom             | MIOL Refractive  |       |               | 12                | 32           |
|     | Acritec twinset    | MIOL Diffractive |       |               | 12                | 32           |

**Abbreviations:** IOL, intraocular lens implant; MIOL, multifocal intraocular lens implant; nm, not mentioned.
Table 3 Characteristics of the 46 groups

| Monofocal groups | Patients (n) (total patients) | Follow-up (weeks) | Average UDVA (LogMAR) | Average UNVA (LogMAR) | Satisfaction rate | Need for spectacle (all spectacles) |
|------------------|------------------------------|------------------|-----------------------|-----------------------|------------------|-----------------------------------|
|                  | n                             | Mean # of patients (SD) (min–max) |                      |                       |                  |                                   |
| Monofocal        | 486                           | 11               | 44.3 (50.8)           | 5                     | 8                | 0.8 (0.23)                         |
| Multifocal       | 2055                          | (13–273)         |                      |                       |                  | 0.78 (0.22)                        |
| Diffractive      | (2055)                        |                  |                      |                       |                  |                                   |
| Refractive       | 448                           | 14               | 32 (29)               | 9                     | 11               | 0.9 (0.06)                         |
| ReSTOR           | (448)                         |                  |                      |                       |                  | 0.2 (0.13)                         |

**Abbreviations:** UDVA, uncorrected distance visual acuity; UNVA, uncorrected near visual acuity; SD, standard deviation; min, minimum; max, maximum.

Table 4 Random effects pooled estimates of uncorrected distance and near visual acuity for IOL implants

| IOL implant          | Distance visual acuity | Near visual acuity |
|----------------------|------------------------|--------------------|
|                      | Mean LogMAR | 95% CI | P* | Mean LogMAR | 95% CI | P* |
| Monofocal            | 0.165        | 0.090–0.240 | <0.001 | 0.470     | 0.322–0.618 | <0.001 |
| Multifocal, all      | 0.093        | 0.088–0.098 | 0.141 | 0.131–0.152 | 0.002 |
| Multifocal, diffractive | 0.105      | 0.098–0.111 | 0.82 | 0.067–0.098 | 0.217 |
| Multifocal, refractive | 0.085       | 0.029–0.140 | 0.217 | 0.118–0.317 | 0.006 |
| ReSTOR               | 0.067        | 0.059–0.076 | <0.001 | 0.064     | 0.046–0.082 | 0.006 |

**Notes:** *P* values for statistical test of the significance of the differences between monofocal versus multifocal, diffractive versus refractive, and ReSTOR other multifocal IOL implants, respectively.

**Abbreviations:** IOL, intraocular lens; CI, confidence interval.

Patient satisfaction and halo
Results of patient satisfaction and presence of halo analyses are shown in Tables 5 and 6. No statistically significant differences between implant types were found for patient satisfaction or halo reports. In most cases, point estimates (IRRs) were close to the null value (1.0), except between diffractive versus refractive IOL implants with regard to halo. Diffractive implants were associated with a lower incidence rate of halo as compared with refractive implants (IRR 0.71, 95% CI: 0.48–1.05), but the difference did not reach statistical significance (*P* = 0.087).

Discussion
Our study compared vision outcomes after multifocal IOL or monofocal IOL implants, and outcomes after multifocal implants differing in physical properties and other characteristics. In this meta-analysis, because we found very few trials comparing head to head monofocal IOLs, we made the
decision to use monofocal IOL arms as a common arm to do indirect comparisons among multifocal IOLs. We did not compare the different types of monofocal IOLs, because this was not our objective and because the experimental design was not appropriate for us to do so.

Although we identified an important number of relevant studies (n = 20), it should be noted that most did not randomize treatments, which could be considered as poor evidence reporting. However, this can be explained by certain ethical constraints. Randomization is acceptable in the early development of an IOL, from the patient’s point of view, because the associated benefit–risk ratio has to be quantified. Subsequently, however, it is much more difficult to promise patients spectacle independence when treatments are randomized in a clinical trial.
and knowing that only patients given a multifocal IOL implant can enjoy freedom from spectacles. This explains why most trials analyzed by this meta-analysis were not randomized.

We found better uncorrected distance visual acuity following multifocal IOL implants than after monofocal implants, which was unexpected from an optics standpoint. It might be that surgeons implanting multifocal IOLs promised their patients freedom from spectacles, although this did not apply to monofocal implants. Perhaps they then performed more precise biometric assessments after the multifocal IOLs in order to ensure that the patients would not need spectacles. This would explain the better uncorrected distance visual acuity findings.

Patient satisfaction was high for all implants, with no difference observed between IOLs. On the top of this ceiling effect, it must be recalled that satisfaction reports were not obtained in a uniform manner across studies, which was likely to engender high uncontrolled variability. Also, satisfaction questions concerned surgical outcomes and did not refer to the

Figure 2 Uncorrected distant visual acuity: random effects pooled LogMAR estimates for diffractive, refractive, and ReSTOR multifocal intraocular lens implants. The y-axis denotes the estimates obtained in different studies as well as the combined (pooled) estimate.
IOLs implanted. Patients undergoing simple cataract surgery always express high levels of satisfaction because their corrected visual acuity improves dramatically. Hence, an outcome questionnaire dedicated to refraction evaluation, such as the NEI-RQL-42, would be more appropriate to capture a patient’s perceived benefit of being free from spectacles.39,40

The main limitation of our study was the distribution of patients between the clinical trials of the different IOL implants. In particular, the numerically superior diffractive multifocal IOLs was especially due to a high number of patients implanted with ReSTOR as compared with the alternative diffractive implant, Tecnis, which was studied in almost 10 times fewer patients than ReSTOR. Also, the total number of patients recruited in clinical trials of all refractive multifocal IOL implants was half that for ReSTOR. Given the aforementioned figures, it would appear that our statistical analysis was more powerful with regard to objective findings for ReSTOR than for the other multifocal IOLs when taken

Figure 3 Uncorrected near visual acuity (VA): random effects pooled LogMAR estimates for monofocal vs multifocal intraocular lens implants. The y-axis denotes the estimates obtained in different studies as well as the combined (pooled) estimate.
null
Table 6 Random effects Poisson regression estimates for comparison of the probability (incidence) of satisfaction and of presence of halo for subgroups of IOL implants

| IOL implant         | Satisfaction | Halo                           |
|---------------------|--------------|--------------------------------|
|                     | IRR 95% CI   | IRR 95% CI                     |
| Monofocal           | 1.00 Reference | 1.00 Reference                  |
| Multifocal all      | 1.03 0.90–1.17| 1.13 0.91–1.39                  |
| Multifocal diffractive | 1.05 0.85–1.31| 0.71 0.48–1.05                  |
| Multifocal refractive | 1.00 Reference | 1.00 Reference                  |
| ReSTOR              | 1.01 0.75–1.36| 0.93 0.54–1.60                  |

Note: *Comparison between ReSTOR and other multifocal IOL implants.

Abbreviations: CI, confidence interval; IRR, incidence rate ratio.

separately. Another limitation was the variability of measurement parameters, especially with respect to spectacle independence which was not expressed similarly across studies.

To our knowledge, no previous meta-analysis has been applied to the present outcomes with multifocal implants. The single existing review article did not involve statistical analysis. Consequently, we could not compare our results with other scientific sources.

On the basis of the present results, we can conclude that multifocal IOLs offer patients better near uncorrected visual acuity than do monofocal implants. Also, ReSTOR provided significantly better visual acuity than other multifocal IOLs.

Spectacle independence was achieved more frequently with multifocal implants than monofocal IOLs, and by multifocal diffractive implants than refractive IOLs. ReSTOR patients also experienced greater freedom from spectacles than patients implanted with other multifocal IOLs. The number of patients observed was insufficient to achieve statistical significance with respect to types of spectacles required (near or distance vision). Also, statistical significance was not attained for patient satisfaction or halo reports. A trend (P = 0.087) was observed, suggesting fewer halos with multifocal diffractive implants compared with refractive IOLs. Hence, the design of an implant could also play a role in the outcome following a multifocal IOL implant.

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Disclosure

GB is an employee of Alcon, France. The other authors disclose no conflicts of interest.

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