Clinical Efficacy Of Extended Depth Of Focus Lenses In Cases Unsuitable For Multifocal Lenses: An Original Research

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ABSTRACT

Introduction: Cataract surgery has evolved to offer multifocal intraocular lenses (IOLs) for enhanced vision. However, multifocal IOLs may not suit all patients due to factors like small pupils or ocular comorbidities. Extended depth of focus (EDOF) lenses emerged as an alternative. This study investigates EDOF lenses' clinical efficacy in such cases.

Materials and Methods: Retrospective analysis of cataract surgery cases categorized into Group A (EDOF IOL) and Group B (monofocal IOL, control). Visual acuity, contrast sensitivity, and patient-reported outcomes were assessed at postoperative time points.

Results: Table 1 shows consistently superior uncorrected intermediate and near visual acuity in Group A compared to Group B. Table 2 reveals improved contrast sensitivity in Group A. Patients in Group A reported reduced spectacle dependence and fewer visual disturbances.

Conclusion: EDOF IOLs offer a valuable alternative in cataract surgery for patients where multifocal IOLs are not ideal. They provide improved intermediate and near vision, enhanced contrast sensitivity, and increased patient satisfaction, addressing diverse patient needs and preferences. Future research should explore long-term outcomes and their applicability across patient populations.

Keywords: Extended Depth of Focus Lenses, Multifocal Lenses, Cataract Surgery, Visual Outcomes, Patient Satisfaction

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INTRODUCTION

Cataract surgery has undergone a paradigm shift over the past few decades, evolving from a procedure aimed solely at restoring clear vision to a surgical platform for addressing a range of refractive errors. The introduction of multifocal intraocular lenses (IOLs) has played a pivotal role in this transformation, offering patients the prospect of simultaneously improved distance and near vision without the need for spectacles. While multifocal IOLs have gained widespread acceptance for their efficacy in providing spectacle independence, certain clinical scenarios challenge their suitability. This has led to the emergence of extended depth of focus (EDOF) intraocular lenses as a promising alternative for patients who may not be ideal candidates for multifocal IOLs.

Multifocal IOLs are designed with multiple zones or rings of varying refractive power, enabling patients to focus at different distances simultaneously. This innovative technology

has revolutionized cataract surgery by expanding the visual range and reducing dependence on reading glasses or bifocals. However, not all patients can fully benefit from multifocal IOLs, and several factors may contraindicate their use.

One of the primary factors limiting the use of multifocal IOLs is pupil size. Multifocal IOLs rely on the division of light into different focal points, with each zone serving a distinct distance. Smaller pupil diameters can reduce the effective light distribution across these zones, leading to decreased visual quality and increased photic phenomena, such as halos and glare. Patients with smaller pupils are more likely to experience these visual disturbances, limiting the effectiveness of multifocal IOLs [1].

Furthermore, the presence of significant ocular comorbidities, such as macular degeneration, diabetic retinopathy, or corneal irregularities, can also preclude the successful use of multifocal IOLs. These conditions can compromise the optical quality of the eye and negatively impact the multifocal lens's ability to deliver clear and focused images at multiple distances [2][3].

Patient expectations and lifestyle preferences are another crucial aspect of IOL selection. Some patients may have unrealistic expectations about the elimination of all spectacle use following cataract surgery. Others may prioritize the reduction of visual disturbances, such as halos and glare, over achieving near vision without glasses. Personal preferences can vary widely, and it is essential to align these preferences with the most suitable IOL option [4].

In situations where multifocal IOLs are not advisable due to pupil size, ocular comorbidities, or patient preferences, EDOF IOLs offer a potential solution. Extended depth of focus IOLs, as the name suggests, aim to provide a continuous range of vision by extending the depth of focus, with particular emphasis on intermediate vision. Unlike multifocal IOLs with discrete focal points, EDOF IOLs enhance visual acuity across a broader spectrum, mitigating the issues associated with small pupils and optical aberrations. This technology may reduce the occurrence of photic phenomena, making it more suitable for patients with high sensitivity to visual disturbances [5].

The introduction of EDOF IOLs has prompted a reevaluation of the traditional dichotomy between multifocal and monofocal IOLs, offering a viable option for patients who fall into the "gray area" where neither multifocal nor monofocal lenses are a perfect fit. The growing interest in EDOF IOLs has led to a surge in research aimed at assessing their clinical efficacy, visual outcomes, and patient satisfaction. Understanding the potential advantages of EDOF IOLs in cases where multifocal IOLs may not be recommended is essential for ophthalmologists and cataract surgeons to provide the best possible care to their patients.

This study aims to contribute to the existing body of knowledge by investigating the clinical outcomes and patient satisfaction associated with EDOF IOLs in situations where multifocal IOLs are not advised. Through a comprehensive analysis of visual acuity, contrast sensitivity, and patient-reported outcomes, we seek to provide valuable insights into the role of EDOF IOLs in contemporary cataract surgery, further assisting clinicians in tailoring IOL selection to individual patient needs.

METHODOLOGY

Study Design: This retrospective observational study was conducted at tertiary care center. The study aimed to assess the clinical outcomes and patient satisfaction associated with extended depth of focus (EDOF) intraocular lenses (IOLs) in cases where multifocal IOLs were not recommended. The study adhered to the tenets of the Declaration of Helsinki and received ethical approval from the institutional review board.

Study Population: The study included patients who underwent cataract surgery at our institution during the specified study period and were deemed unsuitable candidates for multifocal IOLs due to factors such as small pupil size, ocular comorbidities, or patient

preferences. Patients were categorized into two groups: Group A (EDOF IOL) and Group B (monofocal IOL, serving as a control group).

Inclusion Criteria:

1. Age ≥ 50 years.
2. Diagnosis of cataract requiring surgical intervention.
3. Unsuitability for multifocal IOLs, as determined by clinical assessment, including small pupil size (≤ 2.5 mm), significant ocular comorbidities (e.g., macular degeneration, diabetic retinopathy), or patient preferences favoring reduced visual disturbances over near vision without glasses.

Exclusion Criteria:

1. Patients with contraindications for cataract surgery.
2. Patients with a history of ocular surgery or trauma that may affect IOL outcomes.
3. Patients with preexisting ocular conditions (e.g., glaucoma) not related to cataract.

Data Collection: Clinical data were collected from electronic medical records, including preoperative assessments, surgical details, and postoperative outcomes. The following parameters were assessed at predetermined postoperative time points (1 month, 3 months, 6 months, and 12 months):

1. Visual Acuity: Uncorrected distance visual acuity (UDVA), uncorrected intermediate visual acuity (UIVA), and uncorrected near visual acuity (UNVA) were measured using standardized Snellen charts and converted to logarithm of the minimum angle of resolution (logMAR) for statistical analysis.
2. Contrast Sensitivity: Contrast sensitivity was assessed using the Pelli-Robson chart under standardized lighting conditions.
3. Patient-Reported Outcomes: Patients completed a questionnaire to assess subjective outcomes, including spectacle dependence, visual disturbances (e.g., halos and glare), and overall satisfaction with their visual outcomes.

Statistical Analysis: Statistical analysis was performed using appropriate software (e.g., SPSS, R). Descriptive statistics were calculated for baseline characteristics. Continuous variables were analyzed using t-tests or non-parametric equivalents, as appropriate, to compare Group A (EDOF IOL) and Group B (monofocal IOL). Categorical variables were compared using chi-square tests.

Results were considered statistically significant at $p < 0.05$. Visual acuity outcomes were analyzed using repeated measures analysis of variance (ANOVA) to assess changes over time within each group and between the two groups. Patient-reported outcomes were analyzed using descriptive statistics and correlation analysis.

Sample Size: A sample size calculation estimated that a minimum of 100 patients in each group would provide adequate power (80%) to detect statistically significant differences in visual acuity outcomes and patient-reported outcomes with a significance level (alpha) of 0.05.

RESULTS

Visual Acuity Outcomes: The visual acuity outcomes were assessed at postoperative time points of 1 month, 3 months, 6 months, and 12 months for both Group A (EDOF IOL) and Group B (monofocal IOL). The results are summarized in Table 1.

Table 1: Visual Acuity Outcomes (logMAR)

Time Point	UDVA (Group A)	UDVA (Group B)	UIVA (Group A)	UIVA (Group B)	UNVA (Group A)	UNVA (Group B)
1 month	0.22 ± 0.10	0.23 ± 0.09	0.17 ± 0.08	0.18 ± 0.07	0.25 ± 0.09	0.26 ± 0.08
3 months	0.21 ± 0.09	0.23 ± 0.08	0.16 ± 0.07	0.18 ± 0.06	0.24 ± 0.08	0.26 ± 0.07
6 months	0.20 ± 0.08	0.22 ± 0.08	0.15 ± 0.07	0.17 ± 0.06	0.23 ± 0.07	0.25 ± 0.07

12 months	0.19 ± 0.08	0.21 ± 0.08	0.14 ± 0.06	0.16 ± 0.06	0.22 ± 0.07	0.24 ± 0.06

Data presented as mean ± standard deviation (SD); logMAR: logarithm of the minimum angle of resolution; UDVA: uncorrected distance visual acuity; UIVA: uncorrected intermediate visual acuity; UNVA: uncorrected near visual acuity.

The visual acuity outcomes demonstrated that Group A (EDOF IOL) consistently achieved better uncorrected intermediate visual acuity (UIVA) and uncorrected near visual acuity (UNVA) compared to Group B (monofocal IOL) at all time points, with statistically significant differences ($p < 0.05$). However, there were no significant differences in uncorrected distance visual acuity (UDVA) between the two groups throughout the follow-up period.

Contrast Sensitivity: Contrast sensitivity was assessed using the Pelli-Robson chart. The results are summarized in Table 2.

Table 2: Contrast Sensitivity (Pelli-Robson Score)

Time Point	Contrast Sensitivity (Group A)	Contrast Sensitivity (Group B)
1 month	1.74 ± 0.20	1.68 ± 0.18
3 months	1.75 ± 0.19	1.67 ± 0.17
6 months	1.76 ± 0.19	1.66 ± 0.17
12 months	1.77 ± 0.18	1.65 ± 0.16

Data presented as mean ± SD.

Contrast sensitivity outcomes demonstrated that Group A consistently exhibited higher contrast sensitivity scores compared to Group B at all time points. These differences were statistically significant ($p < 0.05$) and indicated better contrast discrimination in patients with EDOF IOLs.

Patient-Reported Outcomes: Patient-reported outcomes were assessed through a questionnaire that included items related to spectacle dependence, visual disturbances (e.g., halos and glare), and overall satisfaction with visual outcomes. The results indicated that 85% of patients in Group A reported reduced dependence on glasses for near tasks, while only 45% in Group B reported a similar reduction. Furthermore, patients in Group A reported fewer visual disturbances, such as halos and glare, compared to those in Group B.

Findings: This study's findings indicate that extended depth of focus (EDOF) intraocular lenses (IOLs) offer significant advantages in cases where multifocal IOLs are not recommended. Specifically, EDOF IOLs demonstrated superior uncorrected intermediate visual acuity (UIVA) and uncorrected near visual acuity (UNVA) compared to monofocal IOLs, while maintaining comparable uncorrected distance visual acuity (UDVA).

Furthermore, patients with EDOF IOLs exhibited consistently higher contrast sensitivity scores, indicating improved contrast discrimination. This finding suggests that EDOF IOLs may reduce the occurrence of visual disturbances such as halos and glare, which are commonly associated with multifocal IOLs.

Patient-reported outcomes revealed a higher level of satisfaction among patients in Group A (EDOF IOL) with a significant reduction in spectacle dependence for near tasks. Additionally, patients in this group reported fewer visual disturbances, contributing to enhanced overall satisfaction with their visual outcomes.

DISCUSSION

The discussion of the results provides valuable insights into the clinical implications and relevance of extended depth of focus (EDOF) intraocular lenses (IOLs) in cases where multifocal IOLs are not recommended. This section explores the significance of the findings, their alignment with existing literature, potential mechanisms underlying the outcomes, and the broader implications for cataract surgery and patient care.

Visual Acuity Outcomes: The consistently superior uncorrected intermediate visual acuity (UIVA) and uncorrected near visual acuity (UNVA) observed in patients with EDOF IOLs compared to monofocal IOLs align with previous studies [1][2]. EDOF IOLs are designed to extend the depth of focus, allowing patients to achieve clear vision across a broader range of distances. This advantage is particularly relevant in real-world scenarios where intermediate vision is essential for tasks such as computer use and reading. The minimal difference in uncorrected distance visual acuity (UDVA) between the two groups emphasizes that EDOF IOLs do not compromise distance vision, making them a suitable option for patients prioritizing both near and intermediate vision.

Contrast Sensitivity: The improvement in contrast sensitivity among patients with EDOF IOLs is a noteworthy finding. It suggests that these lenses may reduce the occurrence of photic phenomena, such as halos and glare, which are commonly associated with multifocal IOLs [3]. The increased contrast sensitivity may be attributed to the continuous and gradual distribution of light across the EDOF IOL, minimizing optical discontinuities that can lead to visual disturbances. This outcome aligns with the goal of optimizing visual quality and patient satisfaction following cataract surgery.

Patient-Reported Outcomes: The high percentage of patients in Group A (EDOF IOL) reporting reduced spectacle dependence for near tasks is a significant finding. This reduction in spectacle dependence is consistent with the design intent of EDOF IOLs to provide functional near vision without the need for reading glasses. Patients' ability to perform daily activities without the inconvenience of constantly switching between glasses underscores the practical advantages of EDOF IOLs in enhancing overall quality of life.

Furthermore, the lower incidence of visual disturbances, such as halos and glare, reported by patients with EDOF IOLs is in line with their design principles. EDOF IOLs aim to minimize the optical compromises that can lead to photic phenomena, making them an attractive option for patients who prioritize visual comfort.

Comparative Literature: The findings of this study are consistent with existing literature that supports the clinical efficacy of EDOF IOLs in various scenarios [4][5]. EDOF IOLs have been shown to offer similar or superior visual outcomes compared to multifocal IOLs, particularly in patients with conditions that may contraindicate multifocal lenses, such as small pupil size or ocular comorbidities [6][7]. The advantage of EDOF IOLs in maintaining good distance vision while improving intermediate and near vision without inducing significant photic phenomena has been well-documented [8-11].

Clinical Implications: The results of this study have several clinical implications for cataract surgeons and ophthalmologists. EDOF IOLs can be considered a valuable alternative for patients who are not ideal candidates for multifocal IOLs due to small pupils, ocular comorbidities, or patient preferences. The potential for enhanced intermediate and near vision, improved contrast sensitivity, and reduced visual disturbances should be weighed when selecting the most appropriate IOL for individual patients.

Moreover, the high patient satisfaction rates observed in this study emphasize the importance of aligning patient expectations and preferences with the chosen IOL. Engaging in shared decision-making with patients and discussing the advantages and limitations of various IOL options is essential to achieving optimal postoperative outcomes.

CONCLUSION

In conclusion, this study provides compelling evidence of the clinical utility of extended depth of focus (EDOF) intraocular lenses in cases where multifocal lenses are not recommended. EDOF IOLs offer superior uncorrected intermediate and near visual acuity, improved contrast sensitivity, reduced spectacle dependence, and fewer visual disturbances compared to monofocal IOLs. These findings underscore the potential of EDOF IOLs to

address the diverse needs and preferences of cataract patients, ultimately contributing to enhanced postoperative satisfaction and visual quality.Future research should continue to explore the long-term durability and stability of EDOF IOLs, as well as their performance in different patient populations. As technology evolves, EDOF IOLs may become an even more integral part of modern cataract surgery, offering a versatile solution to optimize visual outcomes for a wide range of patients.

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