10.21761/jms.v9i01.03

ORIGINAL RESEARCH ARTICLE

A Study of Visual Outcomes After Implantation of Presbyopia-Correcting Intraocular Lenses

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ABSTRACT

Introduction: Presbyopia is a prevalent refractive condition affecting individuals over 40, necessitating effective management strategies. This study evaluates visual outcomes following the implantation of presbyopia-correcting intraocular lenses (IOLs) during cataract surgery.

Material and Methods: A prospective observational study was conducted from September 2022 to February 2024, including 84 patients aged over 40 with age-related cataracts. Preoperative assessments were followed by sutureless phacoemulsification surgery with presbyopia-correcting IOL implantation. Visual acuity, contrast sensitivity, and complications were assessed preoperatively, one month, and three months post-operatively.

Results: The mean age of participants was 55.6 years, with 78.6% achieving best-corrected visual acuity (BCVA) of 6/6 by one month and 91.7% by three months. Significant improvements were noted in both distant and near vision ($p < 0.001$). Contrast sensitivity scores showed 99.0%, scoring 2.0 or above by three months. Complications were minimal; 91% experienced no early complications, and 93% reported no late complications, with posterior capsule opacification observed in 7%.

Conclusion: Presbyopia-correcting IOLs effectively improve visual outcomes post-cataract surgery, demonstrating high patient satisfaction and low complication rates

Keywords: Presbyopia, Intraocular lenses, Cataract surgery, Visual outcomes, Complications.

How to cite this article: Yadav M, Mehrotra N, Tripathi S, Singh KG, Arora P. A Study of Visual Outcomes After Implantation of Presbyopia-Correcting Intraocular Lenses. SRMS J Med Sci. 2024;9(1):16-21.

Source of support: Nil

Conflict of interest: None

Submission: 01-04-2024; **Acceptance:** 01-05-2024; **Published:** 30-06-2024

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INTRODUCTION

Presbyopia is a common refractive condition that affects nearly everyone over the age of 40, leading to difficulties in focusing on near objects. This age-related decline in near vision is a consequence of the natural aging of the eye, specifically the loss of elasticity in the crystalline lens.[1] As the population ages, the demand for effective solutions to manage presbyopia has increased, prompting significant advancements in ophthalmic technology.

Presbyopia-correcting intraocular lenses (IOLs) represent a promising innovation in refractive surgery, particularly for patients undergoing cataract surgery.[2] Unlike traditional monofocal lenses, which provide clear vision at a single distance, presbyopia-correcting IOLs are designed to improve both near and distance vision. [3] These multifocal and accommodating IOLs aim to reduce the dependency on spectacles post-operatively, thus enhancing the overall quality of life for patients.[4]

Numerous studies have demonstrated that the implantation of[5-8] IOLs can lead to satisfactory visual outcomes; however, the extent of these improvements can vary based on individual patient factors, such as pre-existing ocular conditions and the specific type of lens used. The purpose of this study is to evaluate the visual outcomes following the implantation of presbyopia-correcting IOLs in patients undergoing cataract surgery, focusing on factors such as visual acuity, patient satisfaction, and complications associated with these lenses. By analyzing the efficacy of these advanced IOLs, we aim to contribute valuable insights to the ongoing discourse regarding their role in modern ophthalmology and the management of presbyopia.

MATERIAL AND METHODS

This prospective observational hospital-based study was conducted following approval from the institutional ethical committee to evaluate the visual outcomes after the implantation of presbyopia-correcting intraocular lenses. The study population consisted of individuals aged above 40 years who presented to the Ophthalmology Outpatient Department (OPD) and casualty with age-related cataracts and underwent cataract surgery with the implantation of presbyopia-correcting intraocular lenses. Conducted from

September 1, 2022, to February 28, 2024, at the Department of Ophthalmology, Shri Ram Murti Smarak Institute of Medical Sciences, Bareilly, Uttar Pradesh, the study included all patients with cataracts presenting during this period who met the inclusion criteria.

Inclusion criteria comprised patients aged ≥ 40 years who provided informed consent, were diagnosed with visually significant cataracts, and expressed a desire for presbyopia correction. Conversely, exclusion criteria included patients with glaucoma, uveitis, high myopia, intraocular foreign bodies, amblyopia, corneal opacities, advanced diabetic retinopathy, or other retinal pathologies. Additionally, those with intraoperative complications such as zonular dehiscence or vitreous prolapse were excluded.

A comprehensive preoperative assessment was conducted, recording demographic data, cataract history, and visual acuity measurements (Uncorrected visual acuity [UCVA] and best corrected visual acuity [BCVA] for distance and near vision). Color vision testing, contrast sensitivity assessment, intraocular pressure measurement, and slit lamp evaluations were performed. Fundus examinations and B-scan ultrasonography were utilized when necessary, alongside axial length and keratometry measurements for IOL power calculation.

The surgical procedure employed the standard sutureless microincision phacoemulsification technique, conducted under topical anesthesia and mydriatics. This involved creating a corneal incision, performing capsulorrhexis, executing phacoemulsification, and inserting the IOL into the capsular bag via an injector. Post-operative management included administering tapering doses of topical steroids and antibiotics for six weeks. Follow-up assessments at 1 and 3 months post-surgery encompassed visual acuity testing, contrast sensitivity evaluations, slit lamp examinations, and inquiries regarding glare, halos, and difficulties with night driving.

For statistical analysis, categorical variables were presented as counts and percentages, while quantitative data were summarized using means, medians, standard deviations (SD), and interquartile ranges. ANOVA was employed for comparisons of quantitative variables, and the Chi-Square test was used to assess associations between qualitative variables, with Fisher's exact test applied when necessary. A *p-value*< 0.05 indicated statistical significance. Data entry was conducted using Microsoft Excel, and final analyses were performed using SPSS version 25.0.

RESULTS

The present study involves a total of 84 individuals, consisting of 40 males and 44 females. The age group of 40 to 50 years had the highest representation, with 30 participants, which included 17 males (42.5%) and 13 females (29.5%), accounting for 35.7% of the total population. The next age group, 51 to 60 years, comprised 39 participants, with a notable female predominance: 14 males (35.0%) and 25 females (56.8%), representing 46.4% of the total cohort. Lastly, the age group of 61 years and older included 15 participants, consisting of 9 males (22.5%) and six females (13.6%), making up 17.9% of the total sample.

Table 1 shows 13.1% of patients experiencing symptoms for less than one year, 56.0% for one to two years, and 31.0% for more than two years. The mean duration was recorded as 3.95 ± 3.1 years, indicating a significant number of patients sought surgery within the first two years of symptom onset.

Table 2 shows that preoperative UCVA was shown in 57.1% of patients who had a visual acuity of 6/60 or worse, while 34.5% had a BCVA of the same level. At one month post-operation, 23.8% achieved a UCVA of 6/6, and 78.6% attained a BCVA of 6/6. By the third month, these figures improved further, with 65.4% showing a UCVA of 6/6 and 91.7% a BCVA of 6/6. The Chi-square tests indicated a significant difference in visual acuity outcomes post-surgery, with *p-values* less than 0.001, demonstrating the efficacy of the surgical intervention.

In terms of intermediate vision, the results again indicated a positive trend. The percentage of patients achieving N6 vision improved significantly from 27.4% preoperatively to 81.0% at the one-month follow-up and remained stable at 88.1% by the third month. However, N9 vision showed a decrease, with only 10.7% at the three-month mark. The chi-square analysis for intermediate vision revealed a significant *p-value* of 0.001 for the one-month follow-up, while the three-month results showed no significant changes ($p = 0.200$).

The near vision acuity assessment, also outlined in Table 2, reflects a marked improvement following cataract surgery. Preoperative data showed no patients achieving the highest level of near vision (N6). However, at one-month post-surgery, 26.2% of patients had a UCVA of N6, while 80.9% achieved a BCVA of N6. By the third month, these figures increased significantly, with 82.1% achieving UCVA of N6 and 86.9% BCVA of N6. The Chi-square value of 51.01 with a *p-value*of 0.001 indicates

Table 1: Duration between onset of symptoms and uptake of cataract surgery

Duration (Years)	*No. of patients (n)*	*Percentage (%)*
<1 year	11	13.1
1-2 years	47	56.0
>2 years	26	31.0
Mean ± SD	3.95 ± 3.1	

Table 2: Visual acuity assessment

Visual Acuity	*Pre-op UCVA*	*Pre-op BCVA*	*UCVA Vision (1st month)*	*BCVA Vision (1st month)*	*UCVA Vision (3rd month)*	*BCVA Vision (3rd month)*
Distant vision (At 6 meter)						
6/6	-	-	20 (23.8%)	66 (78.6%)	55 (65.4%)	77 (91.7%)
6/9	-	-	36 (42.8%)	16 (19.0%)	15 (17.8%)	5 (6.0%)
6/12	-	5 (6.0%)	20 (23.8%)	1 (1.2%)	8 (9.5%)	1 (1.2%)
6/24	7 (8.3%)	12 (14.3%)	6 (7.1%)	1 (1.2%)	4 (4.7%)	1 (1.2%)
6/36	8 (9.5%)	17 (20.2%)	2 (2.3%)	-	2 (2.3%)	-
6/60	48 (57.1%)	29 (34.5%)	-	-	-	-
<6/60	21 (25.0%)	21 (25.0%)	-	-	-	-
Chi-square	7.7		53.04		15.5	
p-value	0.80		<0.001*		0.001*	
Intermediate vision (At 1 meter)						
N6			23 (27.4%)	68 (81.0%)	68 (81.0%)	74 (88.1%)
N9			43 (51.2%)	15 (17.9%)	9 (10.7%)	10 (11.9%)
N12			15 (17.9%)	1 (1.2%)	6 (7.1%)	-
N18			3 (3.6%)	-	1 (1.2%)	-
Chi-square			50.98		1.63	
p-value			0.001*		0.200	
Near vision (At 25 cm)						
N6			22 (26.2%)	68 (80.9%)	69 (82.1%)	73 (86.9%)
N9			44 (52.4%)	15 (17.9%)	8 (9.5%)	11 (13.1%)
N12			15 (17.9%)	1 (1.2%)	6 (7.1%)	0 (0%)
N18			3 (3.6%)	-	1 (1.2%)	-
Chi-square			51.01		0.72	
p-value			0.001*		0.39	

Table 3: Types of cataracts and visual outcomes after cataract surgery

Type of cataract	*BCVA 6/9 or better (n, %)*	*BCVA 6/36 - 6/9 (n, %)*
Nuclear sclerotic	61 (95.3%)	3 (4.7%)
Posterior subcapsular Cataract	13 (92.9%)	1 (7.1%)
Mature	2 (33.3%)	4 (66.7%)
Chi-square	21.2	$p < 0.001$

Table 4: Contrast sensitivity and dysphotopsias after cataract surgery

Assessment	*1st month (n, %)*	*3rd month (n, %)*	*p-value*
Pelli-Robson score			
Score 2.0	81 (96.4%)	83 (99.0%)	0.311
<2.0–1.5	3 (3.6%)	1 (1.1%)	
<1.5–1.0	0	0	
<1.0	0	0	
Dysphotopsias			
Halo	10 (11.9%)	4 (4.8%)	0.15
Glare	9 (10.7%)	3 (3.6%)	0.07
Starburst	4 (4.8%)	1 (1.2%)	0.17

Table 5: Complications in early and late post-operative periods

Complications	Early post-operative (n, %)	Late post-operative (n, %)
Nil	76 (91%)	78 (93%)
Transient corneal edema	6 (7%)	0 (0%)
Epithelial defect	2 (2%)	0 (0%)
PCO	-	6 (7%)
Decentered IOL	-	0 (0%)
Persistent corneal edema	-	0 (0%)
Total	84 (100%)	84 (100%)

Table 6: Need for secondary interventions

Secondary intervention	No. of patients (n)	Percentage (%)
Nil	82	97.6
Nd capsulotomy	2	2.4
IOL repositioning, wound suturing, AC wash, reposition of Iris	0	0
Total	84	100.0

a statistically significant improvement in near vision following the surgery.

Table 3 shows that among patients with nuclear sclerotic cataracts, an impressive 95.3% achieved a

BCVA of 6/9 or better, with only 4.7% falling below this threshold. In contrast, patients with posterior subcapsular cataracts also exhibited strong outcomes, with 92.9% achieving a BCVA of 6/9 or better, while 7.1% had a BCVA of less than 6/9. However, the mature cataract group showed significantly poorer visual outcomes, as only 33.3% reached a BCVA of 6/9 or better, with a notable 66.7% categorized as having a BCVA below this level. The Chi-square value of 21.2 and a *p-value*of less than 0.001 indicate a statistically significant association between the type of cataract and visual outcomes, suggesting that the type of cataract plays a crucial role in determining post-operative visual acuity.

Table 4 outlines the findings on contrast sensitivity and dysphotopsias at the first and third months post-operatively. The Pelli-Robson contrast sensitivity scores demonstrated a high level of improvement, with 96.4% of patients scoring 2.0 or above at one month, increasing to 99.0% by the third month. Only a small percentage, 3.6% at one month and 1.1% at three months, scored between 1.5 and 2.0, while no patients scored below 1.5 at either time point. *p-value* 0.311 indicate there was no significant difference in Pelli-Robson contrast sensitivity scores at 1st and 3rd-month follow-up.

In terms of dysphotopsias, the occurrence of halos decreased from 11.9% at one month to 4.8% at three months, with a *p-value* of 0.15, indicating no statistically significant change. Similarly, glare complaints reduced from 10.7 to 3.6%, with a *p-value* of 0.07, again suggesting no significant difference. Starburst symptoms also showed a decrease from 4.8 to 1.2%, with a *p-value* of 0.17. Overall, while there was a trend toward improvement in dysphotopsias over time, the changes did not reach statistical significance, indicating that most patients experienced stable contrast sensitivity and a reduction in dysphotopsic symptoms by the third-month post-surgery.

Table 5 summarizes the complications observed during the early and late post-operative periods following cataract surgery. In the early post-operative phase, a significant majority of patients (91%) experienced no complications, while 7% presented with transient corneal edema and 2% had epithelial defects.

In contrast, during the late post-operative period, the majority of patients again reported no complications (93%). However, there were notable occurrences of complications that were not present in the early phase, specifically posterior capsule opacification (PCO) in 7% of patients. Notably, no patients experienced decentered intraocular lenses (IOL) or persistent corneal edema during either period.

Table 6 presents the data on secondary interventions following cataract surgery. A predominant 97.6% of patients (82 out of 84) did not require any secondary interventions, indicating a successful initial surgical outcome. Among those who did require additional procedures, 2.4% (2 patients) underwent neodymium-doped yttrium aluminum garnet (Nd) capsulotomy, while none required intraocular lens (IOL) repositioning, wound suturing, anterior chamber (AC) wash, reposition of Iris.

DISCUSSION

In this study, participants aged 40 to 50 comprised 30 individuals, including 17 males (42.5%) and 13 females (29.5%). The 51 to 60 age group included 39 participants, with 14 males (35.0%) and 25 females (56.8%). For those aged 61 and above, there were 15 participants: 9 males (22.5%) and six females (13.6%). Overall, 40 of the 84 participants (47.6%) were male, and 44 (52.4%) were female.

Similarly, the Rosen *et al*. study found that younger patients were more likely to adopt presbyopia-correcting IOLs, with adoption rates declining with age; patients under 40 showed rates between 52.0 and 60%, while those aged 41 to 50 had rates from 44.0 to 56.9%.[9]

In contrast, the elderly consistently had adoption rates below 10%. Chang *et al*. reported a higher adoption rate of 33.3% among patients younger than 40, particularly those with significant corneal astigmatism, while only 4.5% of those over 81 adopted IOLs, indicating that age-related factors significantly influence technology acceptance.[10]

The current study reveals that a significant percentage of patients exhibited poor preoperative uncorrected visual acuity (UCVA), with 57.1% in the "6/60" category and 25.0% in the "<6/60" category. This finding contrasts with Kohnen *et al*., who provided a more detailed quantitative analysis of UCVA, reporting a mean log MAR value of 0.05 ± 0.122 at 4 m and highlighting the impact of contrast sensitivity and reading speed.[11]

In comparison, Sachdev *et al*. indicated that patients with EROV IOLs experienced better UCVA and higher spectacle independence, suggesting the potential advantages of this technology over those observed in our study.[12]

Additionally, while the present findings showed a notable number of patients with impaired best-corrected visual acuity (BCVA), Hashmi *et al*. noted that a larger proportion of patients typically present with better preoperative visual acuity.[13]

Despite advances in cataract surgery rates, the prevalence of blindness continues to rise in low- and middle-income countries, underscoring the multifaceted challenges of improving visual outcomes. Lastly, disparities in defining "good vision" emerged

when comparing our study with Lindfield *et al*., who categorized BCVA outcomes, emphasizing variability in surgical techniques, patient populations, and post-operative care across different studies.[14]

In our study, at the three-month follow-up, 65.4% of patients achieved an excellent UCVA of 6/6, with a significant majority (91.7%) reaching BCVA of 6/6, indicating positive surgical outcomes.

Perea *et al*. employed a comprehensive assessment strategy, including various visual acuity metrics and higher-order aberrations, providing insights into functional vision beyond basic acuity measures.[15]

In contrast, Prakash *et al*. highlighted the influence of post-operative symptoms such as haloes and glare on patient satisfaction, emphasizing the importance of subjective visual experiences.[16]

Similarly, Wagner *et al*. highlighted sustained improvements in visual acuity over 36 months, .[17] while Shen *et al*. noted better uncorrected near visual acuity in specific cataract types.[18] Furthermore, Prakash *et al*. emphasized the importance of UCVA in predicting overall visual comfort,[16] while Dervenis *et al*. underscored the need to consider preoperative visual acuity and factors such as astigmatism and intraoperative complications that may affect outcomes.[19] These studies collectively highlight the nuanced aspects of post-operative visual function and the various factors influencing patient satisfaction.

In this study, the majority of patients demonstrated excellent near-visual acuity during the first-month follow-up, with significant improvements in UCVA and BCVA. Yeu *et al*. reported similar positive outcomes, highlighting superior near vision in patients with multifocal IOLs compared to monovision lenses.[20]

Sundy *et al*. focused on astigmatism correction, observing a significant reduction in post-operative cylinder values. [21]

Sun *et al*. emphasized the efficacy of presbyopia-correcting IOLs, with substantial improvements in visual acuity and high spectacle independence, although visual disturbances like halos were noted.[2]

Ribeiro *et al*. underscored the importance of patient satisfaction, reporting high levels of functional vision and satisfaction post-surgery.[22]

In the present study, 11.9% of patients reported halos, 10.7% reported glare, and 4.8% reported starbursts at one-month post-surgery, with a significant reduction by three months, where halos were reported by 4.8%, glare by 3.6%, and starbursts by only 1.2%.

This aligns with findings from Kim *et al*., who observed a gradual decline in glare complaints alongside excellent visual acuity and contrast sensitivity.[23]

In contrast, Blau *et al*. reported higher rates of halos and glare with EDOF IOLs, with one study noting 75% of patients free from such symptoms four months post-surgery, yet US FDA trials indicated a greater incidence compared to monofocal IOLs.[24]

Similarly, Fernandez *et al*. found lower patient satisfaction with mesopic vision due to dysphotopsias, with some patients experiencing severe visual disturbances.[25]

However, Koefoed *et al*. demonstrated that glare had minimal impact on contrast sensitivity, suggesting that visual disturbances did not lead to functional impairments in their cohort.[26]

CONCLUSION

In conclusion, this study demonstrated significant improvements in both distant and near visual acuity following cataract surgery. Contrast sensitivity showed notable enhancement over time, and while dysphotopsias such as halos, glare, and starbursts decreased by the three-month follow-up, the changes were not statistically significant. The majority of patients experienced positive surgical outcomes without the need for secondary interventions, indicating the procedure's overall efficacy and safety. It is therefore recommended to consider presbyopia-correcting IOLs while advocating cataract surgery in adults. This study may be designed to be carried out in the younger age groups.

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