International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2022): 7.942

Short Term Visual Outcomes Following a New Trifocal Intraocular Lens Implantation in Patients Undergoing Cataract Surgery through Phacoemulsification

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Abstract: ***Introduction: Traditionally bifocal intraocular lens (IOLs) is implanted following cataract surgery, however, in the recent years trifocal IOLs have emerged as a solution to otherwise unresolved issue of intermediate visual acuity correction. Aim: To study improvement in visual outcomes following trifocal IOL implantation in patients undergoing cataract surgery through phacoemulsification. Materials and Methods: A total of 25 patients (50 eyes; aged 41-70 years; mean age 58.64 years; 68% males) scheduled to undergo cataract surgery using phacoemulsification opting for trifocal IOL implantation were enrolled in the study. Photopic and Mesopic Visual acuity (uncorrected and best corrected), optical aberrations (total, coma, spherical, trefoil, higher order) and contrast sensitivity were measured preoperatively and at day 1, day 7, 1 month and 3 months post-op. intervals. Repeat measures ANOVA and paired 't'-tests were used for comparisons. Result: Significant improvements in near, distant and intermediate visual acuity, contrast sensitivity and decline in optical aberration parameters were seen from day 1 post-operative intervals. The optimization of these improvements occurred at 1 month and persisted till last follow-up at 3 months. Conclusion: Short term visual outcomes of trifocal IOL were promising, particularly with respect to improvement in intermediate visual acuity.***

Keywords: Cataract surgery, trifocal intraocular lens, visual acuity, phacoemulsification

1. Introduction

Cataract surgery has seen a number of improvements during the last fifty years. With the emergence of intraocular lenses (IOLs), visual outcomes following cataract surgery have shown a phenomenal improvement. Traditionally, the IOLs used to be monofocal targeting the correction of distant vision of the patients, however, introduction of bifocal IOLs in the 1980s helped to improve the visual outcomes and patient satisfaction further (Keates et al., 1987)[1]. As a result, cataract surgery now promises independence from spectacles as an additional outcome.

Despite increasing popularity of the bifocal IOLs in providing freedom from spectacles by addressing near and distant vision outcomes, however, one of the limitations of these lenses is their inability to address intermediate vision defects. This problem has soon got redressal by emergence of trifocal and multifocal lenses that promise to address the intermediate vision defects too (Kohnen *et al.*, 2017; García-Pérez *et al.*, 2017; Zamora-de La Cruz *et al.*, 2020)[2,3,4]. The preliminary visual outcomes following use of trifocal intraocular lenses have been promising, encouraging a number of new commercial entrants with new improvisations in design and making it more suitable to all the patients. Recently, Acrysof PanOptix® a trifocal IOL offering from Alcon Inc., Fort Worth, Texas (USA) has been designed to specifically target the unmet need of intermediate vision correction, by creating a third focal point at an intermediate distance of 40 to 60 cm (Rementería-Capelo et al., 2019; Sudhir *et al.*, 2019)[5,6], however, there are only few studies, particularly from India, evaluating its usefulness in patients undergoing cataract surgery using phacoemulsification. Hence, the present study was planned to evaluate the short term visual outcomes following a new trifocal intraocular lens implantation in patients undergoing cataract surgery through phacoemulsification.

2. Material and Method

Study Design: Prospective observational study (Before-after).

Study Place: Anand Hospital and Eye Centre, Jaipur.

Study Population: 25 patients (50 eyes) aged 41 to 70 years (mean age 58.64 years; 68% males) scheduled to undergo bilateral cataract surgery using phacoemulsification and opting for trifocal IOL implantation.

Sample size: 50 eyes.

Year of Study: December 2018 to June, 2019.

Inclusion Criteria: Following was the inclusion criteria for study:

- Adult patients (>40 years) scheduled to undergo cataract surgery using phacoemsulfication.
- Opting for implantation of proposed trifocal IOL in both the eyes.

Exclusion Criteria:

- Preoperative astigmatism greater than 1.5diopters (D)
- Occupational night drivers
- Having history of ocular inflammation, glaucoma or retinal detachment, any neuro-ophthalmic disease, corneal disease or previous refractive corneal or intraocular surgery.
- Abnormal iris or pupil deformation
- Macular degeneration or retinopathy (diabetic, hypertensive)

3. Methodology

All the patients fulfilling the eligibility criteria and providing informed consent to participate in the study underwent a thorough ocular examination of the eye being proposed for surgery for visual acuity (both corrected and uncorrected) for near, distant and intermediate vision under photopic and mesopic conditions 24 hour prior to surgery.

Cataract surgery using phacoemulsification was performed as per standard technique and protocol. The trifocal IOL (AcrySof IQ PanOptix) was implanted with the help of an injector through the main port. Once the IOL was inside the bag, it became unfolded and positioned itself in the capsular bag. Excess viscoelastic was washed out using BSS and aspirated by aspiration cannula. Incisions were checked for leakages. Surgery ended with removal of speculum and disposable sheet. Patient was shifted to recovery room and provided with protective glasses.

Follow-up: Visual acuity, contrast sensitivity and optical aberration measurements were done at day 1, day 7, 1 month and 3 months follow-up intervals. Complications, if any were noted.

Statistical Analysis: Data was analyzed using SPSS 21.0 software. Repeat measures ANOVA and Paired 't'-test were used for comparison of data.

4. Results

Pre-operatively, mean UCVA (photopic) for distance, intermediate and near vision LogMAR values were 0.78±0.19, 0.80±0.13 and 0.84±0.12 respectively. However, on post-operative day 1, these values were 0.09±0.02, 0.32±0.04 and 0.53±0.04 respectively, thus showing a significant improvement in LogMAR values ($p<0.05$). Continued reduction in LogMAR values was seen on subsequent follow-up intervals too. At 3-months follow up, the mean values were 0.01±0.01, 0.30±0.00 and 0.50±0.00 respectively. As compared to baseline, there was reduction in LogMAR values at all the follow-up intervals ($p<0.05$). Similar to UCVA (photopic), UCVA (mesopic), BCVA (photopic) and BCVA (mesopic) LogMAR values also showed a significant reduction following lens implantation. At three months, mean mesopic distance, intermediate and near UCVA LogMAR values were 0.01±0.02, 0.30±0.00 and 0.50±0.00 respectively, mean photopic BCVA LogMAR values were 0.00±0.01, 0.30±0.00 and 0.50±0.00 respectively and mean mesopic BCVA LogMAR values were 0.01±0.02, 0.30±0.00 and 0.50±0.00 (Table 1).

Table 1: Different Uncorrected and Best Corrected Visual acuity parameters at baseline and different follow-up intervals (n=50), Values in Mean±SD (LogMAR)

SN	Parameter	Baseline (Preop.)	Post-op. Day 1	Post-op. Day 7	Post-op. 1 month	Post-op. 3 months	'p' value (Repeat Measures ANOVA)
A. UCVA							
i) Photopic							
1.	Distance	0.78±0.19	0.09±0.02*	0.06±0.03*	0.01±0.02*	0.01±0.01*	<0.001
2.	Intermediate	0.80±0.13	0.32±0.04*	0.32±0.04*	0.30±0.00*	0.30±0.00*	<0.001
3.	Near	0.84±0.12	0.53±0.04*	0.52±0.04*	0.50±0.00*	0.50±0.00*	<0.001
ii) Mesopic							
1.	Distance	0.80±0.18	0.11±0.02*	0.07±0.04*	0.02±0.02*	0.01±0.02*	<0.001
2.	Intermediate	0.82±0.12	0.33±0.05*	0.33±0.05*	0.30±0.00*	0.30±0.00*	<0.001
3.	Near	0.85±0.13	0.53±0.15*	0.53±0.15*	0.50±0.00*	0.50±0.00*	<0.001
B. BCVA							
i) Photopic							
1.	Distance	0.46±0.08	0.09±0.02*	0.05±0.02*	0.01±0.01*	0.00±0.01*	<0.001
2.	Intermediate	0.55±0.09	0.31±0.03*	0.30±0.00*	0.30±0.00*	0.30±0.00*	<0.001
3.	Near	0.69±0.07	0.51±0.03*	0.50±0.01*	0.50±0.00*	0.50±0.00*	<0.001
ii) Mesopic							
1.	Distance	0.46±0.07	0.19±0.02*	0.06±0.03*	0.01±0.02*	0.01±0.02*	<0.001
2.	Intermediate	0.56±0.09	0.33±0.05*	0.32±0.04*	0.30±0.00*	0.30±0.00*	<0.001
3.	Near	0.70±0.07	0.53±0.04*	0.52±0.04*	0.50±0.00*	0.50±0.00*	<0.001
*Significant ($p<0.05$) as compared to pre-op. values (Paired t-test)							

Mean total, coma, spherical, trefoil and higher order optical aberration values were 2.0±1.2, 0.34±0.19, 0.30±0.15, 0.97±2.08 and 0.97±0.49 µ respectively when measured pre-operatively. There was almost 80 to 90% reduction in these values at first post-operative day itself when these values were observed as 0.3±0.1, 0.07±0.02, 0.05±0.02, 0.05±0.02

and 0.09±0.11 µ respectively. During subsequent follow-up intervals, these values ranged from 0.03±0.04 to 0.3±0.1 µ respectively maintaining the % reduction from preoperative values in 80 to 90% range. At 3-months post-operative follow-up these values were 0.2±0.1, 0.08±0.01, 0.03±0.04, 0.04±0.02 and 0.09±0.04 µ respectively thereby showing maintenance of reduced optical aberration (Table 2).

Table 2: Different Optical Aberration parameters at baseline and different follow-up intervals (n=50)
Values in Mean±SD (microns)

SN	Optical Aberration Parameter	Baseline (Preop.)	Post-op. Day 1	Post-op. Day 7	Post-op. 1 month	Post-op. 3 months	'p' value (Repeat Measures ANOVA)
1.	Total	2.0±1.2	0.3±0.1*	0.3±0.0*	0.3±0.1*	0.2±0.1*	<0.001
2.	Coma	0.34±0.19	0.07±0.02*	0.13±0.19*	0.08±0.01*	0.08±0.01*	<0.001
3.	Spherical	0.30±0.15	0.05±0.02*	0.04±0.03*	0.04±0.04*	0.03±0.04*	<0.001
4.	Trefoil	0.97±2.08	0.05±0.02*	0.05±0.02*	0.10±0.10*	0.04±0.02*	<0.001
5.	Higher order	0.97±0.49	0.09±0.11*	0.09±0.12*	0.09±0.04*	0.09±0.04*	<0.001
*Significant (p<0.05) as compared to pre-op. values (Paired t-test)							

Mean modulation transfer function at 5 cycles degree to assess contrast sensitivity was only 0.19±0.05 preoperatively. At 1 day, 7 day, 1 month and 3 months post-operative follow-ups this was 0.65±0.10, 0.67±0.10, 0.66±0.11 and 0.66±0.11 respectively, thus showing nearly 3.5 times increase in contrast sensitivity at post-operative day 1 which persisted till 3 months follow-up interval (p<0.001) (Fig. 1).

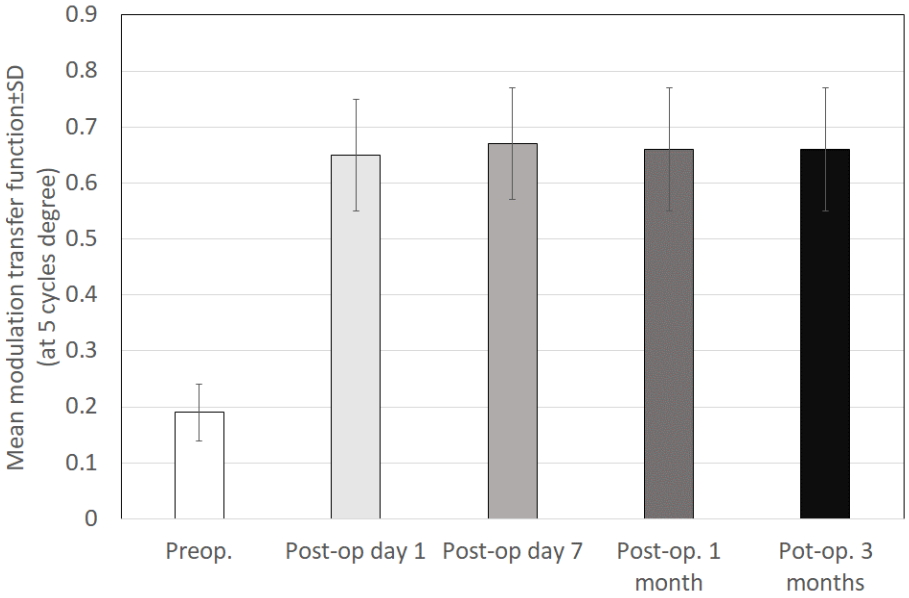

Figure 1: Change in Contrast Sensitivity at different follow-up intervals in comparison with preoperative status

5. Discussion

The present study showed that visual outcomes improved to a spectacle free level for both uncorrected and corrected visual acuity for distance, intermediate and near visions in both photopic and mesopic conditions by first post-operative day itself and showed maintenance of these outcomes till the end of third month. Marked improvements in optical aberrations and contrast sensitivity were also seen. In effect the new trifocal IOL provided very good visual outcomes.

Implantation of trifocal IOL improves intermediate visual function, which is the need of the hour because of increase in the usage of laptops, smartphones and tablets. The diffractive structure of trifocal IOL(PanOptix) allows a higher light utilization, and transmits 88% of light to the retina at a simulated 3.0 mm pupil size. It provides a substantial range of intermediate foci with an optimal intermediate focus at 60 cm (Alfonso et al., 2016)[7]. Significant improvement in near, intermediate and distant ranges without the need for correction as seen in the present study is similar to that reported by Haider *et al.* in their study[8]. Other workers also made similar observations for short-term visual outcomes. In the present study, marked improvements in contrast sensitivity were also seen[3,4,9,10]. In this study, we observed marked (80 to 90%) reduction in optical aberration and nearly 3.5 times improvements in contrast sensitivity. Excellent improvements in contrast sensitivity and aberrations following implantation of trifocal IOL have also been reported by previous workers[10,11]. In view of absence of any adverse effect, we find the new trifocal IOL to be safe and effective.

6. Conclusion

Short term visual outcomes of trifocal IOL were promising, particularly with respect to improvement in intermediate visual acuity.

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