Trifocal Versus Monofocal Intraocular Lenses: A Prospective Assessment of Visual Outcomes and Patient-Reported Satisfaction

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SUMMARY

Aims: To compare trifocal versus monofocal intraocular lenses in terms of postoperative visual outcomes and patient satisfaction.
Material and Methods: In this prospective comparative study, 60 eyes of 46 patients with senile cataract were assigned in a 1:1 ratio to a trifocal IOL (AT LISA tri 839MP, Carl Zeiss Meditec) and a monofocal IOL (CT ASPHINA 203MP/603MP, Carl Zeiss Meditec). The following metrics were assessed before surgery at one, three, and six weeks after the procedure: uncorrected distance visual acuity (UDVA), best-corrected visual acuity (BCVA), uncorrected intermediate visual acuity (UIVA), uncorrected near visual acuity (UNVA), and contrast sensitivity. Using the Near Activity Visual Questionnaire (NAVQ), patient satisfaction as reported by patients was compared between both groups.
Results: Mean UDVA after 6 weeks postoperatively was comparable between the trifocal and monofocal group ($p = 0.27$). Compared to monofocal IOLs, trifocal IOLs had superior uncorrected intermediate visual acuity (UIVA: 0.10 ±0.05) and uncorrected near visual acuity (UNVA: 0.08 ±0.03). Contrast sensitivity, assessed using the Pelli-Robson chart, was similar between the two groups at 6 weeks ($p=0.31$). 93% of patients in the trifocal group reported being independent of their glasses for everyday tasks, indicating improved patient satisfaction, compared to 18% of patients in the monofocal cohort.
Conclusion: When compared to monofocal IOLs, trifocal IOL implantation after phacoemulsification provides superior distance, intermediate, and near visual acuity, along with high levels of spectacle independence and patient satisfaction, without sacrificing contrast sensitivity.
Key words: contrast sensitivity, monofocal intraocular lens, patient satisfaction, phacoemulsification, trifocal intraocular lens, visual acuity

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INTRODUCTION

Cataract surgery is one of the most common ocular surgeries performed, with cataracts continuing to be a major cause of reversible blindness throughout the world. As a result of improvements in phacoemulsification techniques and intraocular lens (IOL) designs, cataract surgery has undergone a transformation from a procedure simply restoring vision to a refractive operation that seeks to provide spectacle independence and the best possible vision at all distances [1,2].

Conventional treatment methods have typically involved the use of monofocal IOLs, which are regarded as the gold standard of therapy due to their ability to produce consistent postoperative results and their outstanding uncorrected distance visual acuity (UDVA). On the other hand, these lenses do not provide patients with functional intermediate or near vision, leading to patients being dependent on glasses for near activities such as reading, using a computer, and interacting with mobile devices [3].

Multifocal IOLs were introduced in the early 1990s to address these constraints. These lenses divide the incoming light into two foci, the far and the near foci, resulting in an improvement in uncorrected near vision [4,5]. However, multifocal IOLs have a few significant disadvantages, including impaired intermediate vision, photic phenomena (e.g., halos and glare), and decreased contrast sensitivity, especially under mesopic conditions [6,7].

Trifocal IOLs have emerged as the next innovation in presbyopia-correcting IOLs, due to the fact that people are increasingly using digital devices and have a greater desire for intermediate visual performance. With the addition of a third focal point for intermediate distances, these lenses are able to enhance performance for tasks, such as working on the computer, looking at the dashboard, and using mobile devices [8,9]. According to current literature, trifocal intraocular lenses (IOLs) provide outstanding visual performance, especially superior uncorrected intermediate visual acuity (UIVA) and improved spectacle independence, compared to bifocal versions [10–12].

There is limited evidence among the Indian population to compare monofocal and trifocal IOLs, particularly in terms of visual results, contrast sensitivity, and patient-reported satisfaction. It is crucial to close this gap in order to optimize IOL selection and counsel the patient accordingly before undergoing cataract surgery. The purpose of this study is to compare the refractive and visual outcomes, contrast sensitivity and patient satisfaction following the implantation of a trifocal versus a monofocal IOL after phacoemulsification.

MATERIALS AND METHODS

This prospective, comparative study was conducted in the Department of Ophthalmology in a tertiary care teaching hospital. The study was conducted for 2 years from January 1, 2023 until December 31, 2024. Patients diagnosed with senile cataract were evaluated for eligibility. Criteria for inclusion in the study were 45–70 years of age, senile cataract (Grade I–III nuclear sclerosis, posterior subcapsular, or cortical cataract), desire for spectacle independence, preoperative refraction of ±5.00 D sphere and ≤ ±1.00 D cylinder, clear cornea, and no substantial ocular disease present. Exclusion criteria were subluxated or complex cataracts, Grade IV nuclear sclerosis, or mature cataracts, history of previous eye surgery or trauma, ocular comorbidities (e.g., glaucoma, corneal degeneration, macular disease), and systemic conditions impacting eyesight (e.g., diabetes, uncontrolled hypertension). All patients received a comprehensive ocular assessment, which included best-corrected visual acuity (BCVA) measured with Snellen and logMAR charts, slit-lamp biomicroscopy for the assessment of the anterior section, fundus examination to exclude retinal or optic nerve pathology, keratometry and axial length assessment utilizing Zeiss IOLMaster 500, measurement of intraocular pressure by Goldmann applanation tonometry, and computation of intraocular lens power utilizing the SRK/T formula. Both Snellen and logMAR charts are tools to measure visual acuity. The Snellen chart uses familiar fractions (6/6, 20/20, etc.), while the logMAR chart spreads those steps out on a logarithmic scale, giving a linear "score" that is easier to track over time.

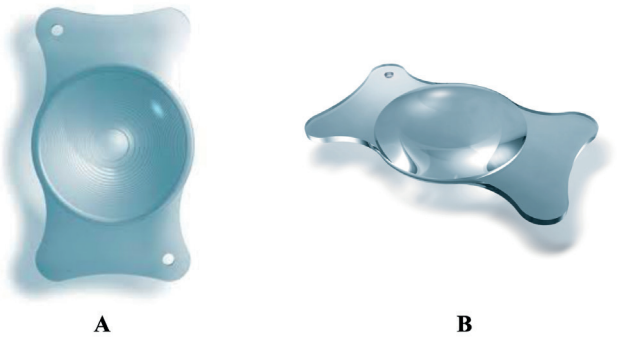


Figure 1. (**A**) – Trifocal IOL AT LISA tri 839MP and (**B**) – Monofocal IOL CT ASPHINA 203M (Carl Zeiss Meditec, Jena, Germany

After applying inclusion and exclusion criteria, a total of 60 eyes of 46 patients were selected and assigned to two groups according to preoperative counseling, lifestyle requirements, and patient preferences. Group 1 (n=30 eyes, Trifocal IOL cohort) received implantation of the AT LISA tri 839MP (Carl Zeiss Meditec, Jena, Germany) (Figure 1A). Group 2 (n = 30 eyes, Monofocal IOL cohort) received implantation of CT ASPHINA 203MP/603MP (Carl Zeiss Meditec, Jena, Germany). (Figure 1B)

Procedure details: All surgeries were performed by a solitary skilled surgeon under peribulbar anesthesia. Standard microcoaxial sutureless phacoemulsification was executed, utilizing the Stellaris Vision System (Bausch & Lomb). A 2.2 mm clean corneal incision was made, followed by continuous curvilinear capsulorhexis, hydrodissection, and nucleus emulsification. Trifocal intraocular lens implantation was executed via a Bluemixs 180 injector. Monofocal intraocular lens implantation was executed via a Skyjet injector. 2% Hydroxypropyl Methylcellulose viscoelastic was used in all surgeries. Upon completion of the surgery, subconjunctival dexamethasone and amikacin were administered. All patients were administered topical gatifloxacin 0.3% combined with prednisolone 1% drops, eight times daily, with a tapering schedule over four weeks. Postoperative evaluations were conducted on day 1, week 1, week 3, and week 6. Primary outcome measures comprised UDVA, BCVA, UIVA at 80 cm, and uncorrected near visual acuity (UNVA). Secondary outcome measures included contrast sensitivity, evaluated with the Pelli-Robson chart, patient satisfaction determined through the validated near activity visual questionnaire (NAVQ), and spectacle independence for daily activities. Data were analyzed utilizing SPSS version 25.0 (SPSS Inc., Chicago, IL, USA). Continuous variables were represented as mean ± standard deviation (SD). The Kolmogorov-Smirnov test evaluated the normality of the distribution. The student's paired t-test was employed for intra-group comparisons between preoperative and postoperative data, and the unpaired t-test was employed for intergroup comparisons. The chi-square test was used for categorical variables. A p-value of less than 0.05 was considered statistically significant.

RESULTS

Sixty eyes of 46 individuals were included in the analysis, comprising 30 eyes in the trifocal IOL group and 30 eyes in the monofocal IOL group. The mean age in the trifocal group was 58.4 ±6.2 years, and 59.1±5.9 years in the monofocal group, which was comparable (p value 0.56). Out of 30 patients in each group, there were 14 males in the trifocal group and 13 in the monofocal group. Tables 1 and 2 show the progressive changes in early postoperative visual outcomes at day 1, week 1, week 3 and week 6 in trifocal and monofocal groups, respectively. At 6 weeks postoperatively, the mean UDVA was logMAR 0.02 ±0.04 in the trifocal group, and logMAR 0.03 ±0.05 in the monofocal group (p = 0.27). No statistically significant difference in distant vision was seen between the two groups (Table 3). The trifocal group had markedly superior UIVA and UNVA compared to the monofocal group. Contrast sensitivity, assessed using the Pelli-Robson chart, was similar between the two groups at 6 weeks (1.65 ±0.12 vs. 1.62 ±0.10, p = 0.31), suggesting that trifocal IOL implantation did not impair contrast sensitivity. Patient-reported satisfaction was evaluated, utilizing the NAVQ. In the trifocal cohort, 93% of patients indicated total spectacle independence for daily tasks, including reading, computer usage, and mobile device interaction. In the monofocal cohort, merely 18% attained spectacle independence for close or intermediate activities, with the majority needing glasses for reading and computing tasks (Table 4).

Table 1. Early Post-operative Visual Outcomes (Trifocal IOL Group, n = 30 eyes)

Parameter	Post-op Day 1	Post-op Week 1	Post-op Week 3	Post-op Week 6	P-value (Progression)
UDVA (LogMAR)	0.25 ±0.08	0.08 ±0.04	0.04 ±0.03	0.02 ±0.04	< 0.001
UIVA (LogMAR)	0.35 ±0.10	0.15 ±0.05	0.12 ±0.04	0.10 ±0.05	< 0.001
UNVA (LogMAR)	0.20 ±0.06	0.10 ±0.03	0.09 ±0.03	0.08 ±0.03	< 0.001
BCVA (LogMAR)	0.08 ±0.03	0.04 ±0.02	0.04 ±0.02	0.04 ±0.02	< 0.001
Contrast Sensitivity (Log Units)	1.40 ±0.15	1.55 ±0.12	1.65 ±0.12	1.65 ±0.12	< 0.001
Refraction (Sphere)	-0.50 ±0.25 D	-0.25 ±0.15 D	-0.10 ±0.08 D	-0.05 ±0.05 D	< 0.001

D – diopter, UDVA – uncorrected distance visual acuity, UIVA – uncorrected intermediate visual acuity, UNVA – uncorrected near visual acuity, BCVA – best corrected visual acuity

Table 2. Early Post-operative Visual Outcomes (Monofocal IOL Group, n = 30 eyes)

Parameter	Post-op Day 1	Post-op Week 1	Post-op Week 3	Post-op Week 6	p-value (Progression)
UDVA (LogMAR)	0.30 ±0.10	0.10 ±0.05	0.05 ±0.04	0.03±0.05	< 0.001
UIVA (LogMAR)	0.50 ±0.12	0.40 ±0.10	0.3 5 ±0.09	0.30 ±0.09	0.005
UNVA (LogMAR)	0.45 ±0.10	0.35 ±0.08	0.30 ±0.07	0.25 ±0.08	0.002
BCVA (LogMAR)	0.10 ±0.04	0.05 ±0.03	0.03 ±0.02	0.03 ±0.02	< 0.001
Contrast Sensitivity (Log Units)	1.50 ±0.10	1.60 ±0.10	1.62 ±0.10	1.62 ±0.10	0.003
Refraction (Sphere)	-0.60 ±0.30D	-0.30 ±0.20 D	-0.15 ±0.10 D	-0.05 ±0.05 D	< 0.001

D – diopter, UDVA – uncorrected distance visual acuity, UIVA – uncorrected intermediate visual acuity, UNVA – uncorrected near visual acuity, BCVA – best corrected visual acuity

Table 3. Final Comparative Outcomes Between IOL Groups at 6 Months

Parameter	Trifocal Group (n=30 eyes) Mean ± SD	Monofocal Group (n=30 eyes) Mean ± SD	P – value
UDVA (LogMAR)	0.02 ±04	0.03 ±0.05	0.27
UIVA (LogMAR)	0.10 ±0.05	0.30 ±0.09	< 0.001
UNVA (LogMAR)	0.08 ±0.03	0.25 ±0.08	< 0.001
Contrast Sensitivity (Log Units)	1.65 ±0.12	1.62 ±0.10	0.31
Spectacle Independence (%)	93%	18%	< 0.001
Photic Phenomena (Incidence)	8%	0%	0.12

UDVA – uncorrected distance visual acuity, UIVA – uncorrected intermediate visual acuity, UNVA – uncorrected near visual acuity

Table 4. NAVQ Score Comparison at 6 Months (Near Activity Visual Questionnaire)

Near Vision Activity	Trifocal Group (n=30 eyes) Mean ± SD	Monofocal Group (n=30 eyes) Mean ± SD	P - value
1. Reading small print (e.g., menu)	0.07 ±0.15	2.13 ± 0.50	< 0.001
2. Reading labels/instructions (e.g., medicine bottles)	0.10 ±0.20	1.90 ±0.45	< 0.001
3. Reading post/mail (e.g., bills)	0.13 ±0.25	1.57 ±0.49	< 0.001
4. Writing and reading own writing (e.g., signing forms)	0.17 ±0.30	1.20 ±0.40	< 0.001
5. Seeing display/keyboard on a computer/calculator	0.23 ±0.35	0.90 ±0.35	< 0.001

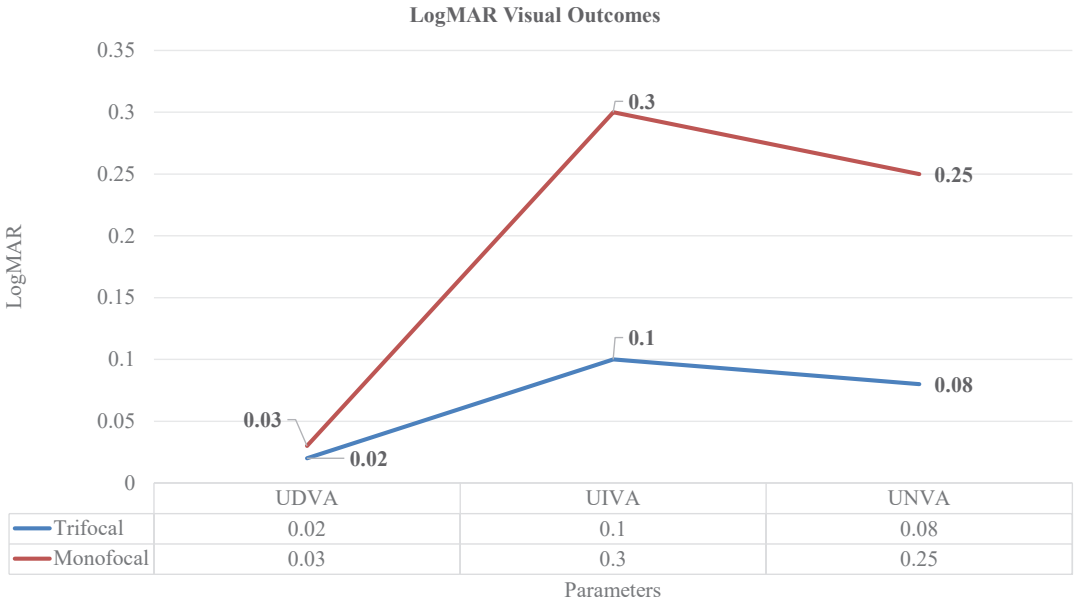
NAVQ – Near Activity Visual Questionnaire

DISCUSSION

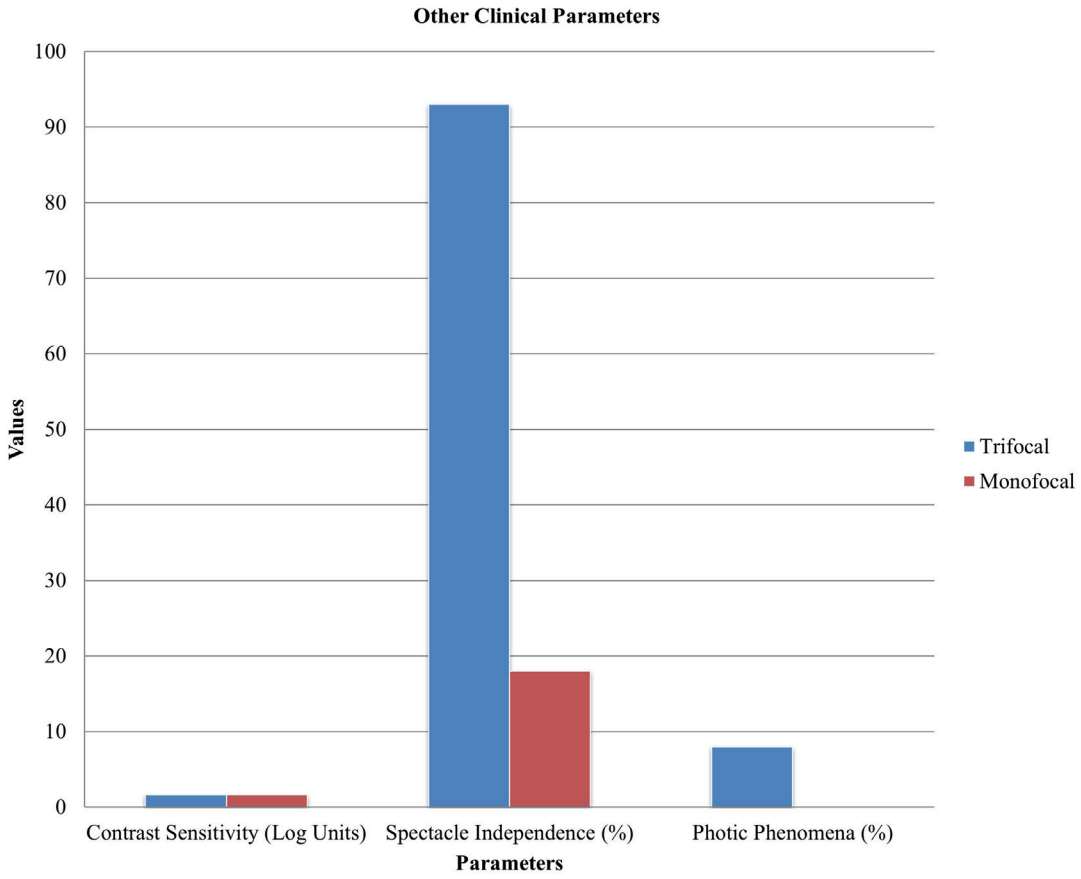
This prospective study evaluated visual outcomes, contrast sensitivity, and patient satisfaction after the implantation of trifocal versus monofocal IOLs following phacoemulsification. The results indicate that trifocal IOLs offer superior uncorrected distance, intermediate, and close visual acuity, enhanced spectacle independence, and increased patient satisfaction, all while maintaining contrast sensitivity.

The trifocal group's distance visual acuity was outstanding, which is in line with that reported in the literature. The mean postoperative monocular UDVA in our sample was 0.06, with a range of -0.10 to 0.30 logMAR. Remarkably, UDVA of 0.00 logMAR or higher was attained by 95% of eyes. These findings are similar to those of Cochener et al. [13], who reported 0.06±0.09 with FineVision IOLs, and Mojzis et al. [9], who used the AT LISA tri 839MP and observed a mean UDVA of –0.03 ±0.09. Intermediate vision, frequently a constraint in bifocal and early-generation multifocal intraocular lenses, was markedly enhanced with trifocal lenses. In our study, 73.3% of eyes attained monocular UIVA of 0.10 logMAR or superior (assessed at 80 cm), aligning with Mojzis et al. [9], who documented a mean UIVA of 0.08 ±0.10 at 66 cm, utilizing the same IOL. Cochener et al. [13] also noted similar intermediate vision results with FineVision trifocal lenses. The middle add power of 1.75 D seems to offer an effective range for activities, such as computer work, dashboard observation, and reading handheld gadgets.

The mean UNVA in the trifocal group (0.08 ±0.03 logMAR) is equally impactful. This logMAR value roughly corresponds to 6/7.5 Snellen or N6 to N8 on the near vision chart, making tasks like reading a newspaper or a menu easily manageable without corrective lenses. In stark contrast, the monofocal group demonstrated no clinically useful unaided near or intermediate vision, necessitating spectacles for all activities within arm's reach. (Graph 1)



Graph 1. Showing comparison of UDVA, UIVA and UNVA in trifocal and monofocal IOL groups
UDVA – uncorrected distance visual acuity, UIVA – uncorrected intermediate visual acuity, UNVA – uncorrected near visual acuity



Graph 2. Showing comparisons of contrast sensitivity, spectacle independence and photic phenomenon between two groups

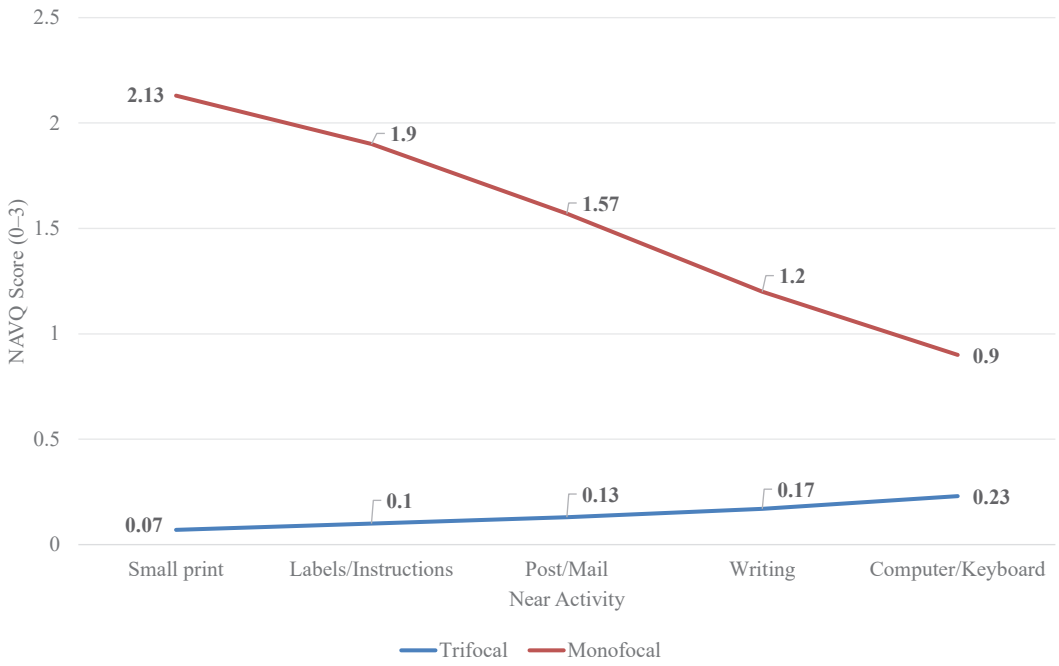
In our work, contrast sensitivity, frequently questioned in relation to multifocal optics, due to the dispersion of light across many foci, was maintained. Pelli-Robson testing indicated no statistically significant difference between the trifocal and monofocal groups ($p = 0.31$), with values remaining within the age-matched normative range. (Graph 2) This corresponds with the findings of Talan et al. [14], who indicated no substantial decrease in contrast sensitivity between trifocal and monofocal lenses. Furthermore, the design of aspheric lenses and the reduction of scatter caused by cataracts probably enhanced the preservation of contrast function in both photopic and mesopic circumstances.

The study addressed patient tolerance for photic phenomena, finding that only 8% of individuals in the trifocal cohort reported challenges with nocturnal driving. This low rate is a marked improvement over older multifocal designs and suggests that the balanced light distribution across the three foci minimizes disruptive side effects. This finding aligns with the literature on the AT LISA trilens, which often reports lower rates of severe dysphotopsia (halos and glare), compared to earlier-generation multifocal lenses, potentially due to the lens's achromatic aberration-correcting features and smooth diffractive steps.

The ultimate measure of success for a refractive IOL is patient satisfaction and the achievement of spectacle independence, particularly in a population where access to multiple pairs of glasses may be a financial or logistical barrier. As per the results of the study, it was concluded that the trifocal IOL showed good VA (0.1 logMAR or better) at far, intermediate, and near distance; high patient satisfaction despite some optical phenomena; and high spectacle independence (93%). (Graph 2)

Patient satisfaction was evaluated with the NAVQ questionnaire, which emphasizes the execution of daily near and intermediate visual tasks without corrective measures. The trifocal cohort exhibited elevated satisfaction, evidenced by a mean NAVQ score of 0.07 **±0.15.** (Graph 3) This surpasses the scores documented by Ristvedt D et al. [15] for other presbyopia-correcting lenses, signifying the superior intermediate performance of trifocal optics. Daily tasks, such as reading fine print, utilizing smartphones, cooking, or gardening, were judged to be more manageable, hence reinforcing the functional advantage.

Regarding spectacle independence, our study revealed that 93% of patients with trifocal IOLs did not require spectacles at any distance. Across all evaluated near tasks, the trifocal group reported minimal difficulty, with mean scores ranging from 0.07 to 0.23 on the 0–3 NAVQ scale. In contrast, the monofocal group exhibited substantially higher difficulty, with mean scores from 0.90 to 2.13, indicating persistent functional limitations



Graph 3. This figure summarizes the patient-reported functional outcomes using the 4-point NAVQ scale (0=No Difficulty, 3=Extreme Difficulty). Lower mean scores indicate superior functional vision with trifocal IOL group
NAVQ – Near Activity Visual Questionnaire

for common near-vision activities. Differences between the groups were highly statistically significant ($p < 0.001$). These findings highlight that trifocal IOLs provide robust and clinically meaningful improvements in patient-reported near-vision performance, enabling greater independence in daily near tasks, compared with monofocal IOLs [16].

This investigation further validated the refractive predictability of the AT LISA tri 839MP, with 90% of eyes attaining a spherical equivalent within ±0.50 D. This aligns with findings from previous studies and demonstrates the reliability of the lens constant, as well as the precision of biometry utilizing the SRK/T calculation [17]. Residual refractive errors were minor and primarily astigmatic, perhaps due to surgically induced astigmatism. Significantly, these residual mistakes did not correspond with diminished visual function or displeasure.

Although multifocal intraocular lenses have traditionally been linked to visual disturbances, such as glare, halos, and challenges in nocturnal driving, our findings indicate that the diffractive trifocal design may mitigate these issues. Merely 4% of individuals in the trifocal cohort experienced challenges with nocturnal driving, a statistic inferior to that generally noted in bifocal intraocular lens trials.

However, the limited sample size, single-center design, and short follow-up duration in this study constrain the generalized ability and long-term relevance of the findings. Comprehensive multicenter trials, with prolonged postoperative monitoring and systematic assessment of dysphotopsias, are necessary to confirm these results and to clarify the function of trifocal intraocular lenses in enhancing refractive outcomes following cataract surgery. Furthermore, comparing the AT LISA tri with other trifocal or extended-depth-of-focus (EDOF) IOLs would further clarify the optimal lens choice in this rapidly evolving field. Addressing surgically induced astigmatism and integrating toric versions of these lenses for patients with significant pre-existing cylindrical power would also be important areas for future research.

In summary, the study firmly establishes the trifocal IOL as the superior choice for cataract patients seeking high levels of spectacle independence and excellent functional vision across all distances, without the conventional penalty of reduced contrast sensitivity.

CONCLUSION

Trifocal intraocular lenses provide significant benefits compared to monofocal intraocular lenses after phacoemulsification. Although both groups attained similar uncorrected distance visual acuity and maintained contrast sensitivity, the trifocal cohort demonstrated significantly enhanced uncorrected intermediate and near visual acuity, leading to considerably greater spectacle independence and improved patient-reported satisfaction. The findings underscore the improved functional visual performance offered by trifocal IOLs. This is more pertinent, given modern visual requirements, including digital device usage and intermediate-distance activities. Achieving these optimal results remains contingent upon careful preoperative counseling and meticulous surgical techniques.

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