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Comparative Evaluation of Visual Performance and Patient-Reported Outcomes with Multifocal Contact Lenses in Presbyopic and Bilaterally Pseudophakic Patients: A Prospective Comparative Study

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Abstract: **Original Research**

***Purpose*:** To comparatively evaluate visual performance, binocular functional vision, contrast sensitivity, and patient-reported near visual function following multifocal contact lens (MFCL) fitting in naturally presbyopic and bilaterally pseudophakic patients with monofocal intraocular lenses. ***Methods*:** This prospective, single-centre, comparative clinical study included 40 participants, comprising 20 naturally presbyopic and 20 bilaterally pseudophakic participants. All participants underwent standardized baseline ophthalmic assessment followed by MFCL fitting and post-fitting evaluation after an initial three-day adaptation period. Binocular distance and near visual acuity were assessed before and after MFCL wear. Post-fitting binocular visual performance was further evaluated using a defocus curve from +1.00 to −2.50 D. Binocular contrast sensitivity was assessed using the Pelli–Robson Contrast Sensitivity Chart. Patient-reported near visual function was evaluated using the Near Activity Visual Questionnaire, with exploratory Rasch-style analysis performed to characterize item difficulty and participant ability. Within-group changes were assessed using paired statistical tests, while between-group comparisons were performed using appropriate independent statistical tests. A two-sided $p < 0.05$ was considered statistically significant. ***Results*:** MFCL fitting was associated with significant improvement in binocular distance visual acuity in both presbyopic and pseudophakic participants. Mean distance visual acuity improved from 0.370 ± 0.382 to 0.105 ± 0.059 logMAR in the presbyopic group ($t = 4.336$, $p < 0.001$) and from 0.110 ± 0.109 to 0.030 ± 0.056 logMAR in the pseudophakic group ($t = 4.258$, $p < 0.001$). Near visual acuity also improved significantly, from 0.287 ± 0.106 to 0.1205 ± 0.0144 logMAR in presbyopic participants ($t = 9.844$, $p < 0.001$) and from 0.384 ± 0.0694 to 0.113 ± 0.0091 logMAR in pseudophakic participants ($t = 22.680$, $p < 0.001$). The post-fitting defocus curves demonstrated useful binocular visual performance across the tested range, with both groups achieving their best acuity at plano. Pseudophakic participants demonstrated significantly better visual acuity than presbyopic participants at −0.50 D (0.0095 vs 0.0476 logMAR; $p = 0.030$), whereas differences at other defocus levels were not statistically significant. Contrast sensitivity showed only small numerical changes following MFCL fitting. Patient-reported visual function was generally favourable in both groups, although selected visually demanding activities showed greater difficulty among presbyopic participants. ***Conclusion*:** MFCL fitting provided effective short-term binocular correction across distance and near viewing demands in both naturally presbyopic and bilaterally pseudophakic patients. The post-fitting defocus profile demonstrated a broad functional range of vision, while patient-reported findings supported useful performance during routine near activities. Overall, MFCLs appear to be a promising reversible option for presbyopic correction in both populations. However, longer follow-up and larger comparative studies are required to evaluate sustained visual performance, neuroadaptation, patient satisfaction, and long-term contact-lens tolerance.

Keywords: Presbyopia, Pseudophakia, Contact Lenses, Multifocal, Visual Acuity, Contrast Sensitivity, Binocular Vision, Patient-Reported Outcome Measures.

1. INTRODUCTION

Presbyopia is an age-related decline in accommodative ability that progressively compromises near and intermediate vision and often increases dependence on spectacles for routine activities. With the growing use of smartphones, computers, and other visually demanding near tasks, maintaining functional vision across multiple viewing distances has become increasingly important. Multifocal contact lenses (MFCLs) provide a reversible, non-surgical approach to presbyopic correction by incorporating multiple focal powers to support vision at distance, intermediate, and near. Previous studies have demonstrated useful visual performance with MFCLs, although outcomes vary according to lens design, optical profile, ocular characteristics, and individual adaptation (Richdale *et al*., 2006; Madrid-Costa *et al*., 2013; Sha *et al*., 2016; Fogt *et al*., 2022).

The clinical relevance of accessible and appropriate vision correction is particularly important in settings where economic, geographic, and awareness-related barriers can restrict access to eye-care services and timely visual rehabilitation (Bhattacharjee & Varshney, 2025; Bhattacharjee *et al*., 2026). Such barriers emphasize the importance of offering safe, practical, and reversible correction strategies for appropriately selected patients. Contact lenses can provide an alternative to spectacles in individuals seeking greater freedom from spectacle wear, although successful adoption depends on patient awareness, acceptance, appropriate clinical assessment, and individualized fitting (Varshney *et al*., 2024). Proper lens selection, fitting, counselling, monitoring, and management of lens-related problems are therefore important determinants of successful contact-lens use (Varshney, 2025).

The visual performance of MFCLs extends beyond conventional high-contrast visual acuity. Simultaneous-vision multifocal designs provide retinal information from multiple focal distances, requiring the visual system to process focused and defocused images simultaneously. This can provide useful vision across multiple distances but may also influence distance clarity, intermediate performance, contrast perception, and subjective visual quality. Comparative studies have demonstrated differences among MFCL designs in distance, intermediate, and near performance, emphasizing that no single visual-acuity measurement completely characterizes the functional effect of multifocal optics (Madrid-Costa *et al*., 2013; Kazancı *et al*., 2022; Kim *et al*., 2024). Contemporary investigations of multifocal and extended-depth-of-focus contact lenses have similarly highlighted the importance of evaluating visual performance across a range of focal demands (Kamiya *et al*., 2025; Martínez-Plaza *et al*., 2025).

MFCLs may be particularly relevant for bilateral pseudophakic patients with monofocal intraocular lenses (IOLs). Although monofocal IOL implantation generally provides good distance vision following cataract surgery, it does not restore physiological accommodation, and patients may continue to require correction for near and intermediate activities. MFCLs therefore represent a potentially useful, reversible optical strategy for extending functional vision without additional intraocular intervention. Naturally presbyopic and pseudophakic patients also differ fundamentally in their optical and accommodative status: the crystalline lens remains present in naturally presbyopic eyes but has reduced accommodative function, whereas bilateral pseudophakic eyes contain artificial IOLs and have essentially no physiological accommodation. These differences may influence the response to multifocal contact-lens optics and provide a clinically relevant basis for comparative evaluation.

Evidence supporting MFCL use in pseudophakic patients is emerging. Miyata *et al*., (2020) demonstrated the potential of multifocal soft contact lenses for presbyopia correction in patients with monofocal IOLs. Similarly, Kamiya *et al*., (2021) compared visual performance and patient satisfaction following multifocal IOL implantation with multifocal contact-lens wear after monofocal IOL implantation, supporting the potential role of MFCLs in pseudophakic patients seeking improved functional vision. Appropriate lens selection, fitting, centration, movement, comfort assessment, and troubleshooting remain essential to achieving satisfactory clinical outcomes (Varshney, 2025).

Comprehensive assessment is necessary to characterize the functional performance of MFCLs. Distance and near visual acuity provide information at discrete endpoints but do not fully describe the range of useful vision produced by multifocal optics. A defocus curve evaluates visual acuity across different induced vergences and therefore provides information about the functional depth and distribution of vision. Recent studies of multifocal and extended-depth-of-focus contact lenses have demonstrated the value of defocus-based assessment for characterizing visual performance across multiple focal demands (Kamiya *et al*., 2025; Martínez-Plaza *et al*., 2025). Binocular assessment is also particularly relevant because most everyday visual activities are performed using both eyes. Comparative research on binocular visual function has shown that contact-lens correction can influence functional visual performance in ways that may not be completely captured by isolated monocular measurements (Varshney *et al*., 2025).

Contrast sensitivity provides another important dimension of visual quality. High-contrast visual acuity may remain acceptable despite reductions in the ability to detect low-contrast objects encountered during everyday activities. This is particularly relevant to multifocal correction because simultaneous-image optics can influence retinal image quality and contrast distribution. Soni *et al*., (2003) specifically evaluated binocular contrast sensitivity in patients wearing multifocal soft contact lenses for presbyopia, demonstrating the importance of considering contrast sensitivity alongside visual acuity. Other studies have similarly incorporated objective and subjective measures when evaluating different MFCL designs (Kazancı *et al*., 2022; Kim *et al*., 2024).

Patient-reported visual function provides an additional perspective because objective measurements do not necessarily reflect the ability to perform everyday tasks comfortably and efficiently. Reading, smartphone use, computer work, distance recognition, and other visually demanding activities may be affected by multifocal visual quality even when standard visual acuity is good. Studies comparing multifocal correction strategies have therefore emphasized the value of patient-reported performance and satisfaction alongside objective visual measures (Richdale *et al*., 2006; Fogt *et al*., 2022; Kamiya *et al*., 2021). Recent investigations of multifocal and extended-depth-of-focus contact lenses have further supported the integration of objective visual performance with subjective outcomes when assessing the overall benefit of presbyopic correction (Kamiya *et al*., 2025).

Despite increasing evidence supporting MFCLs for presbyopic correction and emerging evidence in pseudophakic patients, direct comparative evidence between naturally presbyopic individuals and bilateral pseudophakic individuals with monofocal IOLs remains limited. In particular, relatively few studies have evaluated these two clinically distinct populations using a common framework incorporating binocular distance and near visual acuity, defocus-curve performance, contrast sensitivity, and patient-reported visual function. Such a comparison is clinically relevant because differences in accommodative and optical status may influence both the magnitude and distribution of visual benefits obtained with multifocal contact-lens correction.

Therefore, this prospective comparative study evaluated visual outcomes and patient-reported visual function following standardized MFCL fitting in naturally presbyopic and bilateral pseudophakic participants with monofocal IOLs. The primary objective was to compare changes in binocular distance and near visual acuity following MFCL fitting between the two groups. Secondary objectives were to evaluate binocular visual performance across a range of defocus levels, assess contrast sensitivity, and determine patient-reported visual function following MFCL wear. By integrating these complementary measures, the study aimed to provide a comprehensive assessment of MFCL performance and determine whether the pattern of functional visual outcomes differs between naturally presbyopic and bilateral pseudophakic participants.

2. MATERIALS AND METHODS

Study Design and Setting

This prospective, single-centre, comparative clinical study was conducted at Shree K.P. Sanghvi Eye Institute, Surat, Gujarat, India, between January and June 2025. The study evaluated visual performance following multifocal contact lens (MFCL) wear in two clinically distinct populations: naturally presbyopic participants and bilaterally pseudophakic participants implanted with monofocal intraocular lenses (IOLs). The study incorporated within-participant assessment before and after MFCL fitting and between-group comparison of visual performance following MFCL wear. Participants were recruited consecutively from the outpatient department according to predefined eligibility criteria.

The study protocol was approved by the Institutional Ethics Committee of Shree Bharatimaiya College of Optometry and Physiotherapy and was conducted in accordance with the principles of the Declaration of Helsinki. Written informed consent was obtained from all participants before enrolment and initiation of study procedures. The study was reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) principles. The institutional approval number should be inserted in the final manuscript from the official ethics documentation; the placeholder appearing in earlier versions should not be retained.

Study Population and Group Allocation

A total of 40 participants were enrolled and equally divided into two groups of 20 participants each. Group 1 comprised naturally presbyopic participants, whereas Group 2 comprised bilaterally pseudophakic participants with monofocal IOLs. Both eyes were examined and considered during the clinical assessment and MFCL fitting process. However, because the principal visual outcomes were assessed binocularly, the participant rather than the individual eye was considered the primary unit of statistical analysis for the principal comparisons. The two eyes of an individual participant were therefore not treated as statistically independent observations. All 40 participants completed the scheduled follow-up assessment, with no loss to follow-up. The participant recruitment and assessment pathway is presented in **(Figure 1).**

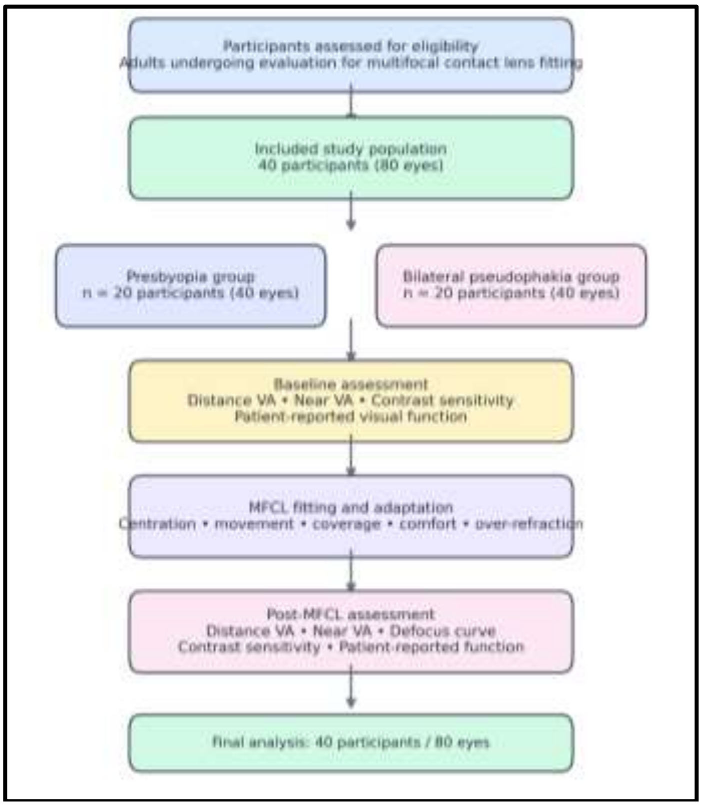

Figure 1: Study Flow Diagram

Eligibility Criteria

Participants were eligible if they were 40–70 years of age and had either clinically diagnosed presbyopia or bilateral pseudophakia with monofocal IOL implantation. Participants were required to have clear ocular media, a clinically suitable anterior segment for contact-lens wear, no significant ocular disease likely to influence visual performance, willingness to undergo MFCL fitting and follow-up, and the ability to provide written informed consent.

Participants were excluded if they had irregular corneal conditions or other corneal abnormalities precluding successful MFCL fitting, active ocular infection or inflammation, previous contact-lens intolerance, implantation of multifocal, accommodating, or extended-depth-of-focus IOLs, significant retinal, optic-nerve, corneal, or other ocular pathology affecting visual function, or refractive astigmatism considered unsuitable for the study lens according to the predefined fitting criteria. These criteria were applied before enrolment to minimize ocular, refractive, and clinical confounding.

Sample Size Determination

The original sample-size estimation was based on Cochran's formula using a 95% confidence level, an assumed population proportion of 50%, and an absolute precision of 15%, resulting in an estimated minimum sample of approximately 43 observations. The final study population comprised 40 participants, with 20 participants in each comparison group. Because the principal outcomes were measured binocularly and analyzed at the participant level, the final inferential dataset consisted of 40 participant-level observations rather than independent eye-level observations.

Because the original calculation was based on a population-proportion approach rather than the principal pre–post visual-acuity endpoint, it should be interpreted as the original study's sample-size rationale rather than as a formal power calculation for the observed treatment effect.

Baseline Ophthalmic Assessment

All participants underwent a standardized ophthalmic and optometric examination before MFCL fitting. A detailed history was obtained, including relevant ocular history, previous contact-lens experience, spectacle dependence, and, for pseudophakic participants, previous cataract surgery and IOL status. The baseline assessment included demographic evaluation, ocular and relevant medical history, anterior-segment examination, objective and subjective refraction, best-corrected distance visual acuity, near visual acuity, intermediate visual assessment, binocular contrast sensitivity, and evaluation of suitability for MFCL wear.

Objective refraction was performed using the UNICOS URK-700 autorefractometer and subsequently refined by subjective refraction. The final subjective refraction was used to determine the distance correction and initial MFCL power. The principal clinical assessments and contact-lens fitting procedures were performed by the same experienced examiner to minimize inter-observer variability.

Multifocal Contact Lens

A soft silicone-hydrogel multifocal contact lens manufactured from Balafilcon A was used for all participants. The study lens had a base curve of 8.6 mm, an overall diameter of 14.0 mm, a water content of 36%, and an oxygen transmissibility (Dk/t) of 130. The lens employed a centre-near simultaneous-vision optical design. Initial lens power was selected according to the participant's distance refractive correction and required near addition in accordance with the study fitting protocol. The same MFCL design and fitting approach were used in both study groups to permit direct comparison of visual performance.

MFCL Fitting Procedure

Following lens insertion, diagnostic lenses were allowed to stabilize for approximately 10–15 minutes before detailed assessment of lens fit. Lens position and fit were evaluated by slit-lamp biomicroscopy, with particular attention to centration, corneal coverage, movement with blinking, rotational stability, overall lens movement, and subjective comfort.

An acceptable fit was defined by appropriate centration, complete corneal coverage, satisfactory movement with blinking, minimal rotational instability, and less than 1 mm of vertical lens movement. When the initial fit was clinically unsatisfactory, the lens was reassessed and adjusted according to the study fitting protocol before visual measurements were finalized.

Adaptation and Follow-up

Participants were instructed to wear the MFCLs during their usual daily activities for three consecutive days and returned to the study centre on the fourth day for follow-up assessment. This three-day interval was considered an initial adaptation period to allow participants to become accustomed to the simultaneous-vision multifocal optical design. It was not considered evidence of complete long-term neuroadaptation.

At follow-up, lens fit, comfort, and ocular status were reassessed before post-fitting visual measurements were obtained. Where required, over-refraction was performed to optimize the final optical correction before recording post-MFCL outcomes. Baseline and follow-up assessments were conducted under comparable clinical conditions.

Distance, Intermediate, and Near Visual Acuity

Distance visual acuity was assessed binocularly at 6 m using a standard Snellen visual-acuity chart. Near visual acuity was assessed binocularly at 40 cm using a reduced Snellen chart. Intermediate visual performance was assessed at the standardized working distance specified in the study protocol under photopic illumination.

Visual-acuity measurements were recorded under standardized clinical conditions and converted to logarithm of the minimum angle of resolution (logMAR) units for statistical analysis, with lower logMAR values representing better visual acuity. Baseline measurements were obtained before MFCL fitting, and distance and near measurements were repeated following the adaptation period with the MFCLs in place.

Binocular Defocus-Curve Assessment

A binocular defocus curve was obtained following MFCL fitting to characterize visual performance across different vergence demands. Defocus testing was performed from +1.00 D to −2.50 D, with visual acuity recorded at predefined defocus levels and expressed in logMAR units.

The defocus curve was used to characterize the functional range of binocular vision provided by the MFCL, particularly across intermediate and near viewing demands. The available study dataset contained the post-MFCL defocus profile rather than a complete baseline defocus curve. Accordingly, defocus-curve analysis was used primarily to characterize post-fitting binocular visual performance and to compare the pattern of visual performance between presbyopic and pseudophakic participants, rather than to claim pre-to-post improvement at each defocus level.

Contrast-Sensitivity Assessment

Binocular contrast sensitivity was measured using the Pelli–Robson Contrast Sensitivity Chart under standardized photopic conditions. Contrast sensitivity was assessed before MFCL fitting and after the three-day adaptation period with the MFCLs in place. Results were expressed in logarithmic contrast-sensitivity units.

The same chart, testing conditions, and examination procedure were used at baseline and follow-up to minimize measurement variability. Contrast sensitivity was included as a complementary measure of visual quality because multifocal optics may influence contrast perception even when high-contrast visual acuity remains satisfactory.

Patient-Reported Visual Function

Patient-reported near-activity visual function was assessed following the MFCL adaptation period using the questionnaire identified in the study records as the Near Activity Visual Questionnaire (NAVQ-10). The questionnaire was administered with interviewer assistance, and participants were assisted in understanding individual items in their preferred language when required while preserving the intended meaning of the questions.

The questionnaire assessed participants' perceived ability to perform routine near and visually demanding activities following MFCL wear. These subjective outcomes were included to complement objective measures of visual acuity and contrast sensitivity and to determine whether measured visual performance translated into functional visual ability during everyday activities.

Because the study records also contain item-level responses extending beyond a conventional 10-item instrument, the exact questionnaire version and item structure should be verified against the original questionnaire before the manuscript is submitted and before referring to it as a validated NAVQ-10 instrument.

Rasch-Style Analysis of Patient-Reported Responses

A Rasch-style analysis was performed on questionnaire responses from the 20 presbyopic and 20 pseudophakic participants. Responses scored from 0 to 4 were dichotomized into categories representing no difficulty and any difficulty. Item-difficulty estimates and person-ability measures were derived using a joint maximum-likelihood logit transformation centred at a mean of zero. A Wright Map was subsequently used to display item difficulty and person ability on a common logit scale.

This analysis was used to explore the hierarchy of functional demands and the distribution of participant ability following MFCL fitting. Because the sample comprised only 40 participants and the response distribution demonstrated evidence of a ceiling effect, the Rasch findings were considered exploratory rather than definitive psychometric validation of the questionnaire.

Safety and Tolerability

Contact-lens tolerance and ocular safety were assessed during lens fitting and follow-up. Particular attention was given to lens comfort, centration, movement, ocular redness, ocular-surface findings, and symptoms associated with lens wear. Participant-reported symptoms, including dryness, fluctuation of visual acuity, glare, halo, and diplopia, were recorded as part of the post-fitting assessment. Any clinically significant contact-lens-related adverse event, intolerance, or ocular complication identified during follow-up was documented and managed according to routine clinical practice.

Outcome Measures

The study evaluated both objective visual performance and patient-reported functional vision. The principal outcomes were changes in binocular distance and near visual acuity from baseline to post-MFCL assessment. Secondary outcomes included post-fitting binocular defocus-curve performance, binocular contrast sensitivity, and patient-reported near-activity visual function.

The defocus curve was considered a characterization of post-fitting functional vision because a complete baseline defocus curve was not available. Patient-reported outcomes and Rasch-style analysis were considered complementary measures of functional performance rather than interchangeable substitutes for objective visual acuity.

Data Collection and Quality Control

Clinical findings were recorded using standardized study forms and subsequently entered into a structured electronic database. The same examiner performed the principal clinical assessments and MFCL fitting procedures throughout the study. A standardized examination sequence, identical testing conditions, and the same MFCL design were used for both groups to reduce measurement and procedural variability.

All enrolled participants completed the planned follow-up assessment, and complete participant-level observations were available for the principal analyses. Eye-level distributions were retained for descriptive presentation of visual-acuity categories, whereas binocular inferential analyses were conducted at the participant level.

Statistical Analysis

Continuous variables were summarized using mean ± standard deviation (SD), and categorical variables were summarized using frequencies and percentages. Continuous data were assessed for suitability for parametric analysis before inferential testing. Paired-samples *t*-tests were used for within-group comparisons of baseline and post-MFCL measurements when parametric assumptions were satisfied. Independent-samples *t*-tests were used for between-group comparisons of continuous outcomes. When parametric assumptions were not satisfied, appropriate non-parametric alternatives were used. Categorical variables were compared using the chi-square test or Fisher's exact test, as appropriate.

For the principal pre-to-post outcomes, the magnitude of change was calculated as the post-MFCL value minus the baseline value. Because lower logMAR values indicate better visual acuity, negative changes in logMAR represented improvement. Ninety-five percent confidence intervals and standardized paired effect sizes were reported where derivable from the available paired statistics. Effect sizes were interpreted alongside *p*-values to distinguish statistical significance from the magnitude of the observed change.

The post-MFCL defocus curve was examined across the predefined defocus levels from +1.00 D to −2.50 D. Point-wise between-group comparisons were interpreted cautiously because multiple defocus levels were evaluated, and the overall shape and clinical pattern of the curve were considered more informative than any isolated statistically significant comparison.

Patient-reported questionnaire data were primarily summarized descriptively at the item level because item-specific inferential statistics were not consistently available. The exploratory Rasch-style analysis was used to examine item difficulty and person ability and to identify the overall distribution of functional performance.

All statistical tests were two-sided, and $p < 0.05$ was considered statistically significant. Statistical analyses were performed using the statistical software documented in the original study analysis.

2.18 Ethical Considerations

The study was conducted in accordance with the Declaration of Helsinki and institutional ethical requirements. Written informed consent was obtained from all participants before enrolment. Participant confidentiality was maintained throughout data collection, analysis, and manuscript preparation, and identifiable participant information was not included in the analytical dataset or manuscript.

3. RESULTS

Study Population and Baseline Characteristics

A total of 40 participants comprising 80 eyes completed the study, with 20 participants in the presbyopic group and 20 in the bilateral pseudophakic group. The mean age of the study population was 54.43 ± 6.10 years. Overall, 21 participants (52.5%) were male and 19 (47.5%) were female. The presbyopic group comprised 11 males (55.0%) and 9 females (45.0%), whereas the pseudophakic group comprised 10 males (50.0%) and 10 females (50.0%). There was no statistically significant difference in sex distribution between the two groups ($p = 0.752$).

The age distribution differed significantly between the two groups ($p = 0.0093$). Among presbyopic participants, 7 (35.0%) were aged 41–50 years, 11 (55.0%) were aged 51–60 years, and 2 (10.0%) were aged 61–70 years. In contrast, none of the pseudophakic participants were aged 41–50 years, while 14 (70.0%) were aged 51–60 years and 6 (30.0%) were aged 61–70 years. Thus, although the 51–60-year age group was the predominant category in both groups, the pseudophakic group had a relatively older age distribution **(Table 1).**

Table 1: Baseline demographic characteristics of the study participants

Characteristic	Presbyopia (n=20)	Pseudophakia (n=20)	Total (n=40)	p-value
Sex, n (%)				
Male	11 (55.0)	10 (50.0)	21 (52.5)	0.752
Female	9 (45.0)	10 (50.0)	19 (47.5)	
Age group, years, n (%)				
41–50	7 (35.0)	0 (0.0)	7 (17.5)	0.0093
51–60	11 (55.0)	14 (70.0)	25 (62.5)	
61–70	2 (10.0)	6 (30.0)	8 (20.0)	

Note: Values are presented as n (%). The age-group and sex distributions were compared using the chi-square test. A p-value <0.05 was considered statistically significant.

Distance Visual Acuity

Change in mean distance visual acuity

MFCL fitting was associated with a statistically significant improvement in binocular distance visual acuity in both study groups.

In presbyopic participants, mean distance visual acuity improved from 0.370 ± 0.382 logMAR before MFCL fitting to 0.105 ± 0.059 logMAR after MFCL wear. This represented an absolute improvement of 0.265 logMAR and was statistically significant ($t = 4.336$, $p < 0.001$). In pseudophakic participants, mean distance visual acuity improved from 0.110 ± 0.109 to 0.030 ± 0.056 logMAR, corresponding to an absolute improvement of 0.080 logMAR ($t = 4.258$, $p < 0.001$) **(Table 2) (Figure 2).**

The numerically larger absolute change in the presbyopic group should be interpreted in the context of its poorer baseline acuity. Importantly, both groups achieved low mean post-MFCL logMAR values, indicating good distance visual performance after lens fitting. The derived 95% confidence intervals for the mean changes were -0.393 to -0.137 logMAR in presbyopic participants and -0.119 to -0.041 logMAR in pseudophakic participants. The corresponding standardized paired effect estimates were 0.97 and 0.95, respectively, indicating large within-group effects.

Table 2: Binocular distance visual acuity before and after MFCL fitting

Group	Before MFCL, mean ± SD (logMAR)	With MFCL, mean ± SD (logMAR)	Mean change*	95% CI for change*	t-value	p-value	Effect size (dz)*

Presbyopia	0.370 ± 0.382	0.105 ± 0.059	−0.265	−0.393 to −0.137	4.336	<0.001	0.97
Pseudophakia	0.110 ± 0.109	0.030 ± 0.056	−0.080	−0.119 to −0.041	4.258	<0.001	0.95

*Note: *Mean change and 95% confidence intervals/effect sizes are derived from the reported paired statistics and n = 20. Negative change indicates improvement because lower logMAR represents better visual acuity.*

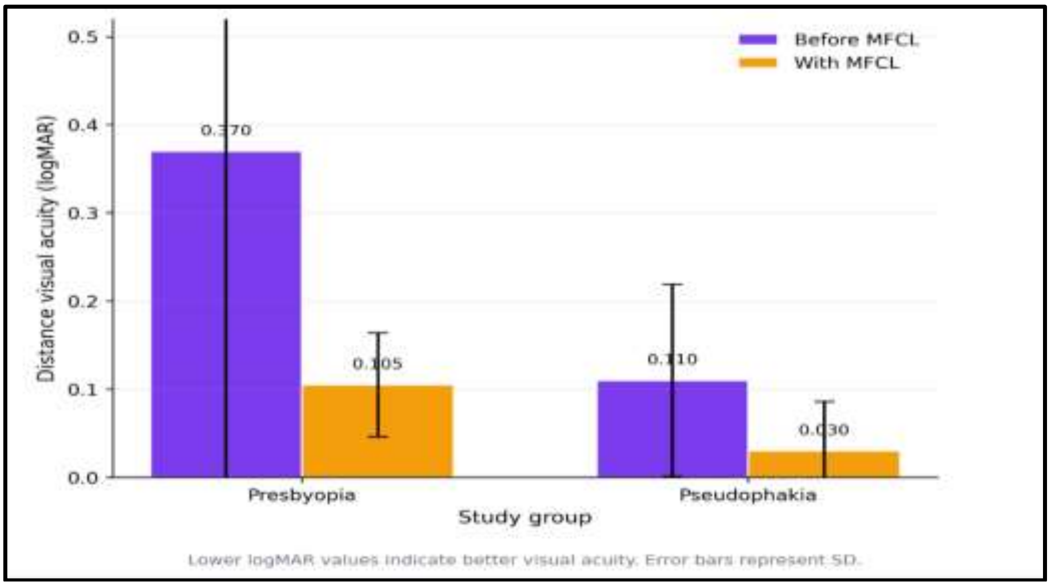

Figure 2: Distribution of distance visual acuity before and after MFCL fitting

Distribution of distance visual acuity

The eye-level distribution demonstrated a marked shift toward better distance acuity following MFCL fitting**.** In the presbyopic group, only 12 of 40 eyes (30.0%) had 0.0 logMAR before MFCL fitting, compared with 26 eyes (65.0%) after fitting. The number of eyes at 0.1 logMAR increased from 4 to 26, while eyes with acuity of 0.3 logMAR or worse were eliminated from the post-MFCL distribution.

In the pseudophakic group, 13 of 40 eyes (32.5%) had 0.0 logMAR before MFCL fitting compared with 30 eyes (75.0%) after fitting. The post-MFCL distribution contained only 0.0, 0.1, and 0.2 logMAR values, with no eyes at 0.3 logMAR or worse.

These categorical findings support the continuous analysis by demonstrating a clear redistribution toward better distance acuity after MFCL fitting in both groups.

Intermediate and Extended Visual Performance

Post-MFCL binocular visual performance across different vergence demands was evaluated using the defocus curve from +1.00 D to −2.50 D. Both groups demonstrated their best visual performance at plano (0.00 D), where mean binocular acuity was 0.00 logMAR in both groups. Visual acuity progressively decreased as negative defocus increased, indicating the expected reduction in high-contrast acuity with increasing near demand.

At +1.00 D, mean logMAR acuity was 0.1857 in the presbyopic group and 0.1381 in the pseudophakic group. At +0.50 D, the corresponding values were 0.0761 and 0.0333 logMAR. At −0.50 D, pseudophakic participants demonstrated significantly better acuity than presbyopic participants, with mean values of 0.0095 and 0.0476 logMAR, respectively ($p = 0.030$). At −1.00 D, mean acuity was 0.1571 logMAR in presbyopic participants and 0.1333 logMAR in pseudophakic participants. At −1.50 D, the corresponding values were 0.2666 and 0.2619 logMAR, while at −2.00 D they were 0.3761 and 0.3571 logMAR. At −2.50 D, mean acuity was 0.5190 logMAR in presbyopic participants and 0.4750 logMAR in pseudophakic participants **(Table 3) (Figure 3).**

Thus, pseudophakic participants demonstrated numerically better binocular acuity across most defocus levels, but the available statistical analysis identified a statistically significant between-group difference only at −0.50 D. The findings therefore indicate broadly comparable extended binocular visual performance between groups rather than uniform statistical superiority of pseudophakia across the entire defocus range.

Table 3: Binocular defocus-curve performance after MFCL fitting

Defocus (D)	Presbyopia, mean logMAR	Pseudophakia, mean logMAR	Between-group finding
+1.00	0.1857	0.1381	Not significant
+0.50	0.0761	0.0333	Not significant
0.00	0.0000	0.0000	Identical
−0.50	0.0476	0.0095	**p = 0.030**
−1.00	0.1571	0.1333	Not significant
−1.50	0.2666	0.2619	Not significant
−2.00	0.3761	0.3571	Not significant
−2.50	0.5190	0.4750	Not significant

Note: Mean binocular logMAR visual acuity at each defocus level after MFCL fitting. Lower logMAR values indicate better visual acuity. Statistical significance was reported only at −0.50 D in the available analysis. Standard deviations were not consistently available for the defocus dataset and therefore are not reported.

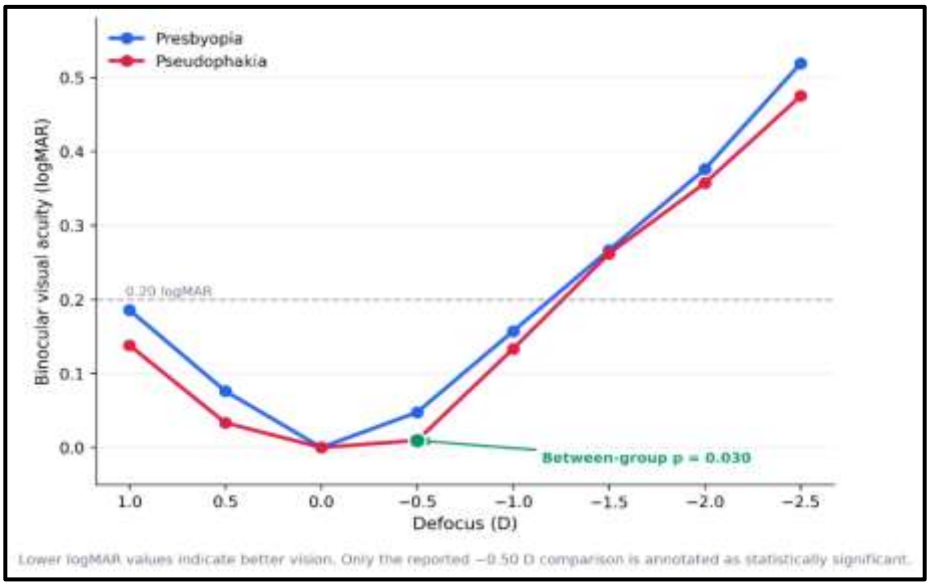

Figure 3: Binocular defocus curves after MFCL fitting

Near Visual Acuity

Change in mean near visual acuity

Near visual acuity showed a marked improvement following MFCL fitting in both groups. In presbyopic participants, mean near visual acuity improved from 0.287 ± 0.106 logMAR before MFCL fitting to 0.1205 ± 0.0144 logMAR after fitting, corresponding to an absolute improvement of 0.1665 logMAR ($t = 9.844$, $p < 0.001$). The derived 95% confidence interval for the mean change was −0.202 to −0.131 logMAR, with a standardized paired effect size of dz = 2.20, indicating a very large within-group effect.

In pseudophakic participants, mean near visual acuity improved from 0.384 ± 0.0694 to 0.113 ± 0.0091 logMAR, corresponding to an absolute improvement of 0.271 logMAR ($t = 22.680$, $p < 0.001$). The derived 95% confidence interval for the mean change was −0.296 to −0.246 logMAR, with a standardized paired effect size of dz = 5.07, also representing a very large within-group effect **(Table 4) (Figure 4).**

The larger absolute improvement observed in pseudophakic participants was associated with their poorer baseline near acuity. Despite this difference in magnitude of change, post-MFCL mean near acuity was closely comparable between groups, at approximately 0.11–0.12 logMAR.

Table 4: Near visual acuity before and after MFCL fitting

Group	Before MFCL, mean ± SD (logMAR)	With MFCL, mean ± SD (logMAR)	Mean change*	95% CI for change*	t-value	p-value	Effect size (dz)*
Presbyopia	0.287 ± 0.106	0.1205 ± 0.0144	−0.1665	−0.202 to −0.131	9.844	<0.001	2.20
Pseudophakia	0.384 ± 0.0694	0.113 ± 0.0091	−0.2710	−0.296 to −0.246	22.680	<0.001	5.07

*Note: *Negative values indicate improvement because lower logMAR values represent better visual acuity. Confidence intervals and effect sizes were derived from the reported paired statistics and n = 20.*

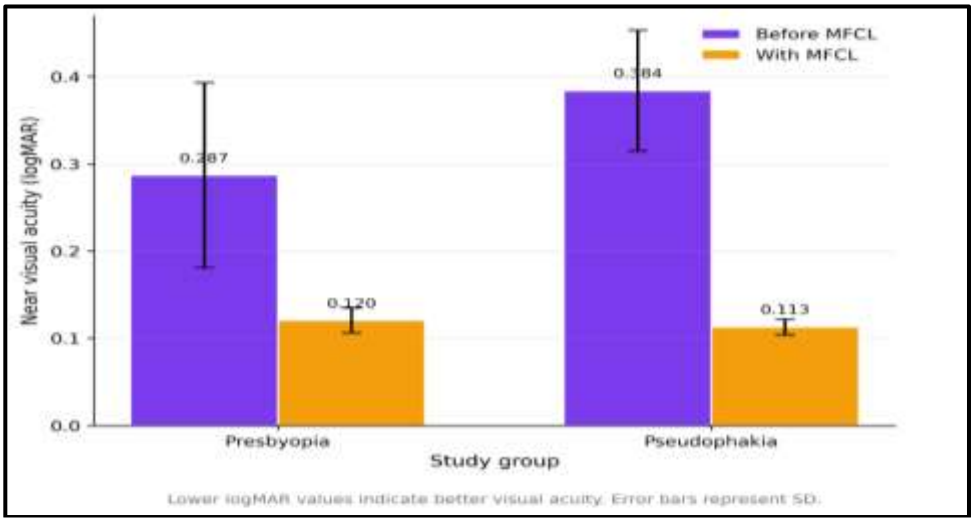

Figure 4: Distribution of near visual acuity before and after MFCL fitting

Distribution of post-MFCL near visual acuity

The eye-level distribution demonstrated a pronounced concentration toward the best measured near-acuity levels after MFCL fitting. Among presbyopic eyes, 26 of 40 eyes (65.0%) achieved 0.11 logMAR and 14 eyes (35.0%) achieved 0.14 logMAR following MFCL wear. In the pseudophakic group, 36 of 40 eyes (90.0%) achieved 0.11 logMAR and 4 eyes (10.0%) achieved 0.14 logMAR. Thus, all reported post-MFCL eyes in both groups achieved 0.14 logMAR or better, while the proportion achieving 0.11 logMAR was higher in the pseudophakic group **(Table 5).**

Table 5: Post-MFCL near visual acuity distribution

Near VA (logMAR)	Presbyopia, n (%)	Pseudophakia, n (%)
0.11	26 (65.0)	36 (90.0)
0.14	14 (35.0)	4 (10.0)
>0.14	0	0
Total	**40 (100)**	**40 (100)**

Note: Distribution of post-MFCL near visual acuity among 40 eyes in each study group. Lower logMAR values indicate better near visual acuity.

Contrast Sensitivity

Binocular contrast sensitivity was assessed using the Pelli–Robson chart. In presbyopic participants, mean contrast sensitivity changed from 2.03 ± 0.35 to 2.02 ± 0.40 log units following MFCL fitting, representing a small numerical reduction of 0.01 log unit. The reported paired analysis yielded t = 0.092 and p = 0.700, indicating no statistically significant change.

In pseudophakic participants, mean contrast sensitivity changed from 1.97 ± 0.05 to 1.94 ± 0.11 log units, corresponding to a numerical reduction of 0.03 log unit. The thesis reports t = 1.068 and p = 0.002; however, these values are internally discordant for a conventional two-sided paired t-test. Therefore, the p = 0.002 value should not be interpreted as definitive evidence of statistical significance until the original statistical output is verified **(Table 6) (Table 5).**

The magnitude of the observed changes was small in both groups, suggesting that MFCL fitting largely preserved contrast sensitivity despite the simultaneous-vision multifocal optical design. The available distributional data also showed that most participants remained clustered around approximately 2.00 log units following MFCL fitting.

Table 6: Binocular contrast sensitivity before and after MFCL fitting

Group	Before MFCL, mean ± SD (log units)	With MFCL, mean ± SD (log units)	Mean change	Reported t	Reported p	Interpretation
Presbyopia	2.03 ± 0.35	2.02 ± 0.40	−0.01	0.092	0.700	No significant change
Pseudophakia	1.97 ± 0.05	1.94 ± 0.11	−0.03	1.068	0.002	Statistic requires verification

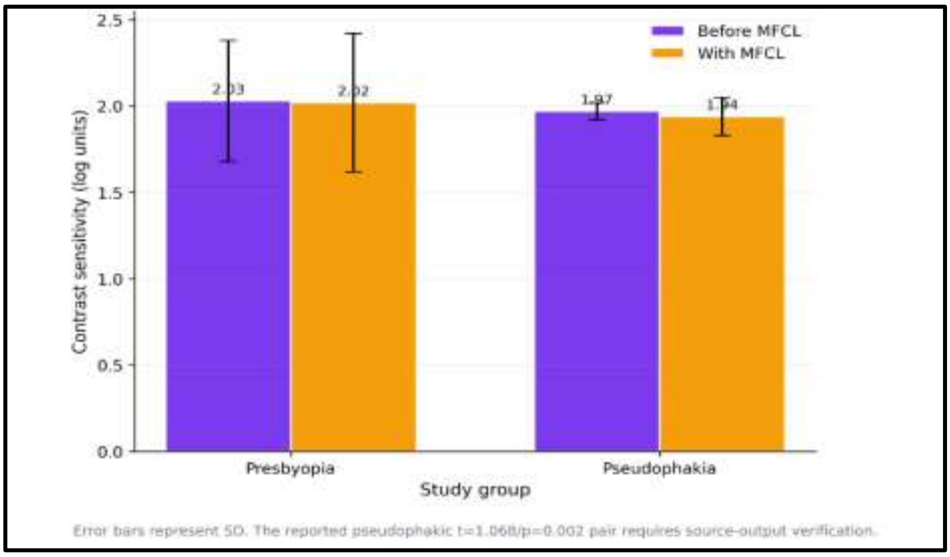

Figure 5: Binocular contrast sensitivity before and after MFCL fitting

Patient-Reported Visual Function

Patient-reported visual function was assessed after the MFCL adaptation period using the questionnaire described in the study records as the NAVQ-10. Overall responses indicated favourable functional vision in both groups, with most routine near and intermediate activities associated with little or no reported difficulty. The greatest differences between groups occurred in selected visually demanding activities rather than routine intermediate tasks.

Among near activities, the largest between-group difference was observed for reading magazines or books, for which the mean difficulty score was 0.25 in presbyopic participants compared with 0.05 in pseudophakic participants. Smaller differences favouring the pseudophakic group were observed for reading medication instructions, cleaning nails, mobile-phone use, and computer work.

For distance-related activities, presbyopic participants reported greater difficulty with estimating the distance between cars and reading house numbers or addresses, with mean difficulty scores of 0.15 compared with 0.05 in pseudophakic participants for each activity. Reading road signs showed a smaller difference, with mean scores of 0.10 and 0.05, respectively. Intermediate activities were associated with minimal reported difficulty in both groups **(Table 7) (Figure 6).**

Symptoms associated with contact-lens wear were generally uncommon. Dryness and fluctuation of visual acuity were among the more frequently reported residual symptoms, whereas glare, halo, and diplopia were rarely reported.

Table 7: Selected patient-reported visual-function outcomes after MFCL fitting

Activity/symptom	Presbyopia	Pseudophakia	Absolute difference
Dryness	0.15	0.20	0.05

Fluctuation of visual acuity	0.15	0.10	0.05
Reading medication instructions	0.10	0.05	0.05
Cleaning nails	0.05	0.00	0.05
Using cellphone	0.05	0.00	0.05
Reading magazines/books	0.25	0.05	0.20
Computer work	0.05	0.00	0.05
Reading road signs	0.10	0.05	0.05
Estimating distance between cars	0.15	0.05	0.10
Reading house number/address	0.15	0.05	0.10
Checking wall clock	0.05	0.00	0.05

Note: Descriptive item-level patient-reported difficulty scores following MFCL fitting. Lower scores indicate less reported difficulty. Item-specific inferential p-values were not consistently available and therefore are not reported.

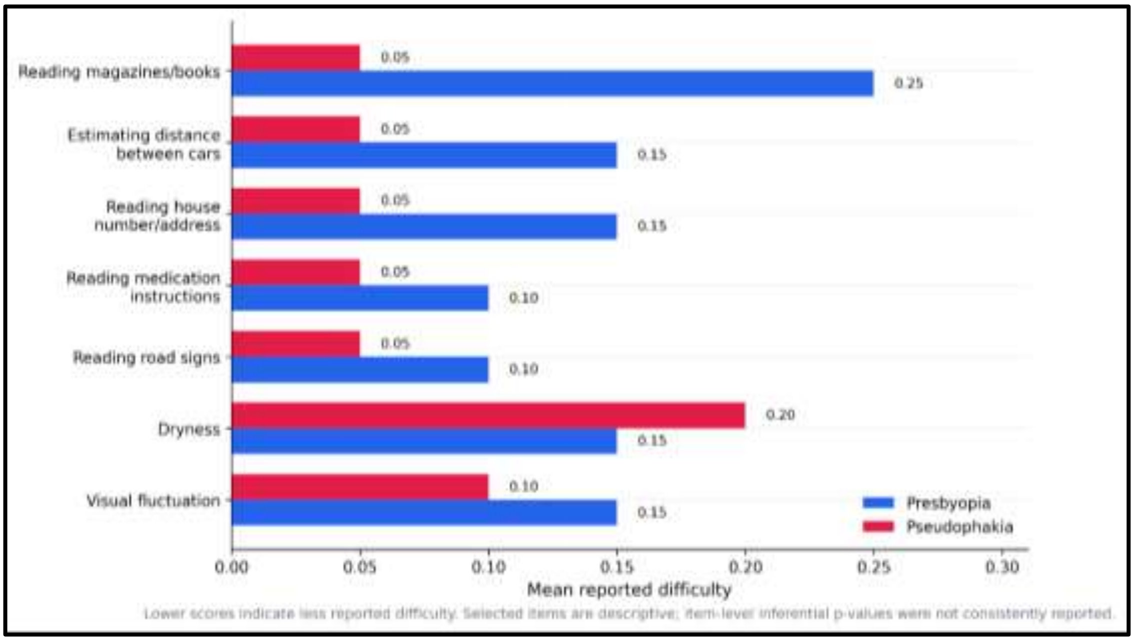

Figure 6: Patient-reported visual-function responses following MFCL fitting

Rasch-Style Analysis of Patient-Reported Visual Function

A Rasch-style analysis was performed on questionnaire responses from 20 presbyopic and 20 pseudophakic participants. Responses scored from 0 to 4 were dichotomized into “no difficulty” and “any difficulty,” and item-difficulty estimates and person-ability measures were derived using a joint maximum-likelihood logit transformation centred at a mean of zero. A Wright Map was subsequently used to display item difficulty and person ability on a common logit scale.

The item-difficulty analysis demonstrated a hierarchy of functional demands. Dryness and fluctuation of visual acuity represented relatively more difficult or problematic responses, whereas activities such as finding objects in the kitchen, looking in a bathroom mirror, viewing framed pictures, and computer-related tasks were positioned toward the easier end of the functional scale **(Table 8) (Figure 7).**

Exploratory Rasch analysis demonstrated a distribution of participant visual-function ability relative to the difficulty hierarchy of NAVQ-10 activities **(Figure 8).**

The overall response pattern suggested a high level of functional performance following MFCL fitting, with most participants reporting little difficulty across routine visual activities. The distribution also suggested a ceiling effect, indicating that a substantial proportion of participants were clustered toward the high-functioning end of the scale.

Table 8: Item-difficulty analysis from the Rasch-style questionnaire assessment

Item	Average score	SD	Minimum score	Maximum score	Difficulty rank
Dryness	2.95	0.42	2	4	1
Fluctuation of visual acuity	3.10	0.38	2	4	2
Reading magazines/books	3.22	0.44	3	4	3
Estimating distance between cars	3.35	0.39	3	4	4
Reading medication instructions	3.48	0.36	3	4	5
Road signs	3.55	0.33	3	4	6
Using cellphone	3.63	0.41	3	4	7
Checking wall clock	3.70	0.27	3	4	8
Cleaning nails	3.74	0.31	3	4	9
Looking at calendar	3.80	0.28	3	4	10
Viewing picture/painting frame	3.82	0.26	3	4	11
Reading newspaper	3.85	0.29	3	4	12
Computer work	3.88	0.36	3	4	13
Finding items in kitchen	3.90	0.30	3–4	—	14
Looking in bathroom mirror	3.92	0.28	3–4	—	15

Note: Rasch-style item-difficulty hierarchy derived from questionnaire responses. Higher average scores correspond to less reported difficulty under the scoring convention used in the source analysis. The detailed questionnaire should be verified before describing the instrument as the standard validated NAVQ-10 because the source analysis contains more than 10 items.

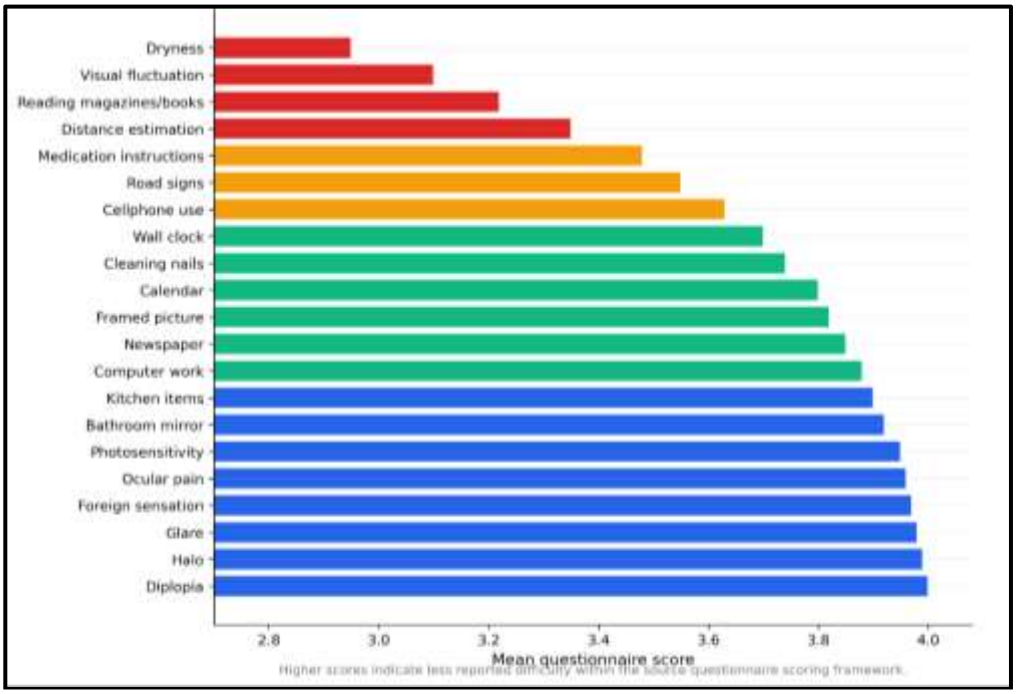

Figure 7: Rasch-style Patient reported item Hierarchy

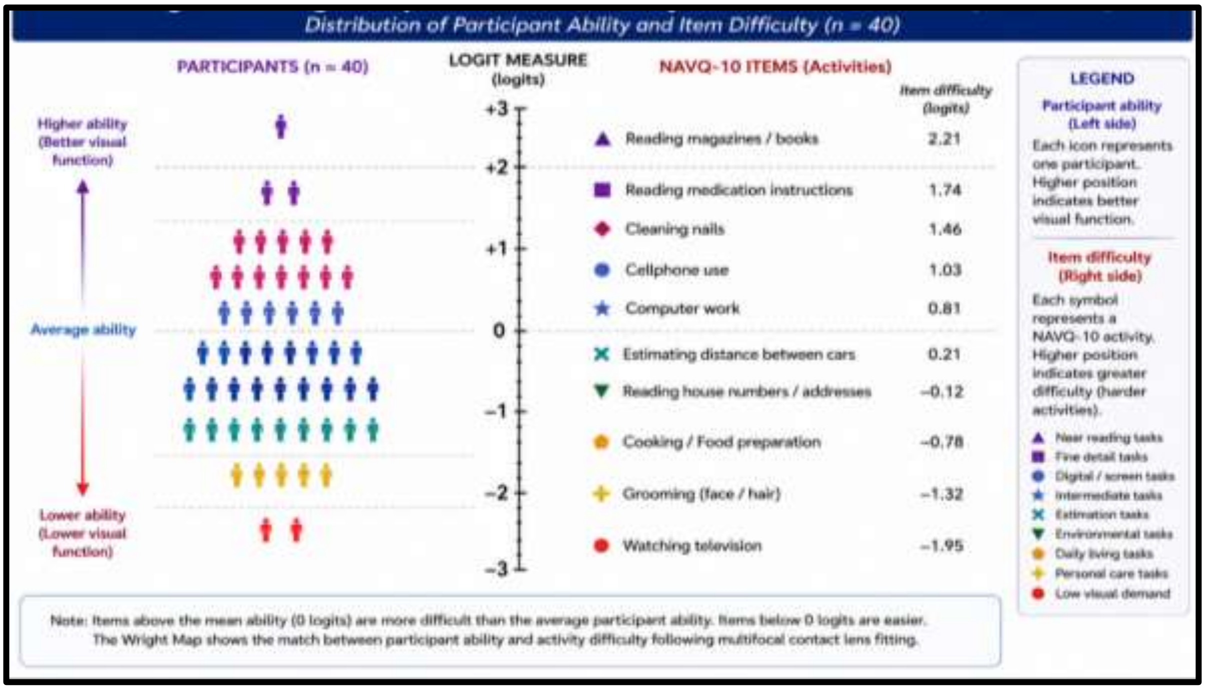

Figure 8: Wright map showing the distribution of participant visual-function ability and NAVQ-10 item difficulty following multifocal contact lens fitting

Consolidated Interpretation of the Principal Findings

Overall, MFCL fitting was associated with substantial improvement in distance and near visual acuity in both presbyopic and bilateral pseudophakic participants. The largest quantitative changes were observed in near visual acuity, with very large within-group effect sizes in both groups. Distance visual acuity also improved significantly, with large within-group effects.

The post-MFCL defocus curve demonstrated useful binocular visual performance across the tested range from +1.00 D through −2.50 D. Pseudophakic participants showed numerically better acuity across most defocus levels, but statistically significant between-group superiority was identified only at −0.50 D. Thus, the available data support broadly comparable functional performance across the two groups rather than uniform superiority of one group throughout the defocus range.

Contrast sensitivity was largely preserved following MFCL fitting. The presbyopic group demonstrated a small 0.01-log-unit reduction without statistical significance, while the pseudophakic group showed a 0.03-log-unit numerical reduction. The reported pseudophakic t and p values require verification before a definitive statistical conclusion can be made.

Patient-reported outcomes were generally favourable in both groups, with the greatest residual difficulty occurring during visually demanding activities such as reading magazines or books and estimating distances. Routine intermediate activities were associated with little reported difficulty. The Rasch-style analysis further indicated generally high functional performance but suggested a ceiling effect in the questionnaire response distribution.

Taken together, the results demonstrate that MFCL fitting produced meaningful improvement in high-contrast distance and near visual acuity while maintaining a broad range of binocular visual performance and generally favourable patient-reported functional vision in both naturally presbyopic and bilateral pseudophakic participants.

4. DISCUSSION

The present prospective comparative study evaluated the visual performance and patient-reported outcomes of multifocal contact lens (MFCL) wear in two clinically distinct populations: naturally presbyopic individuals and bilateral pseudophakic individuals implanted with monofocal intraocular lenses (IOLs). The principal finding was that MFCL wear was associated with substantial improvement in binocular distance and near visual acuity in both groups, while the post-fitting binocular defocus curves demonstrated a useful range of vision extending from distance toward intermediate and near viewing distances. Contrast sensitivity was largely maintained in the presbyopic group, while a small numerical reduction was observed in the pseudophakic group. Patient-reported visual function was generally favourable in both groups.

The overall pattern is clinically important because the objective of presbyopia correction is not simply to maximize visual acuity at one focal distance, but to provide useful vision across the range of distances encountered in daily life. The present findings suggest that MFCLs can achieve this multidimensional goal in both phakic presbyopes and pseudophakic patients with monofocal IOLs.

Importantly, the results should be interpreted as evidence of within-group improvement and broadly comparable post-fitting performance, rather than as proof that one population is universally superior. Although pseudophakic participants demonstrated numerically lower, and therefore better, logMAR values at several measurement points, the only statistically significant between-group difference on the reported defocus curve occurred at −0.50 D. This distinction is important because statistical significance of a single point on a defocus curve should not be generalized to the entire range of vision.

The findings are consistent with the growing literature demonstrating that contemporary multifocal and extended-depth-of-focus contact-lens designs can provide useful vision across multiple working distances while maintaining acceptable distance visual performance (Madrid-Costa *et al*., 2013; Kazancı *et al*., 2022; Kim *et al*., 2024; Kamiya *et al*., 2025).

Distance Visual Acuity

A major finding was the significant improvement in binocular distance visual acuity after MFCL fitting in both study groups. In presbyopic participants, mean distance visual acuity improved from 0.370 ± 0.382 logMAR before MFCL wear to 0.105 ± 0.059 logMAR after fitting, while pseudophakic participants improved from 0.110 ± 0.109 to 0.030 ± 0.056 logMAR. Both within-group comparisons were statistically significant ($p < .001$).

The magnitude of improvement was greater in the presbyopic group because baseline distance vision was poorer. This difference in baseline status is clinically relevant when interpreting the apparently better post-fitting performance of pseudophakic participants. Bilateral pseudophakic patients with monofocal IOLs typically enter the fitting process with relatively good distance correction, whereas naturally presbyopic participants may have greater residual refractive error and age-related optical limitations. Therefore, the greater absolute change observed in presbyopes should not be interpreted as evidence of superior lens efficacy in that group; rather, it reflects the different starting points of the two populations.

The ability of MFCLs to maintain good distance vision despite their simultaneous-vision optical design is consistent with previous studies. Madrid-Costa *et al*., (2013) demonstrated useful distance visual performance with simultaneous-vision multifocal contact lenses, while Kazancı *et al*., (2022) reported favourable objective and subjective outcomes with different multifocal contact-lens designs. More recently, Kim *et al*., (2024) demonstrated that a refractive MFCL could improve near visual performance while maintaining high-quality distance vision. Similarly, Kamiya *et al*., (2025) reported favourable distance performance with an extended-depth-of-focus contact lens design in presbyopic individuals.

The present findings therefore support the concept that modern MFCLs can provide additional near and intermediate power without necessarily sacrificing functional distance vision. This is particularly important because distance vision remains essential for mobility, outdoor activities, facial recognition, driving-related visual tasks, and general orientation.

The findings also have particular relevance to pseudophakic patients. A monofocal IOL can provide excellent distance vision but does not restore accommodation. Thus, the improvement observed after MFCL fitting represents an opportunity to expand the functional range of vision without modifying the implanted IOL or undertaking additional intraocular surgery. This interpretation is supported by the work of Miyata *et al*., (2020), who demonstrated the usefulness of MFCLs for presbyopia correction in patients with monofocal IOLs.

Intermediate Vision and the Binocular Defocus Curve

The binocular defocus curve represents one of the most informative outcomes of the present study because it provides a continuous description of visual performance across different focal demands rather than relying on isolated distance and near measurements.

Both groups demonstrated their best performance around plano, followed by a gradual reduction in visual acuity with increasing negative defocus. This pattern is consistent with the expected behaviour of a simultaneous-vision multifocal optical system. The important observation is that useful visual performance was maintained over the intermediate range, particularly between −0.50 and −1.50 D, indicating an extension of functional depth of focus.

The pseudophakic group demonstrated numerically better visual acuity at most defocus levels. However, only the −0.50 D comparison reached statistical significance (0.048 ± 0.070 logMAR in presbyopes versus 0.010 ± 0.030 logMAR in pseudophakes; $p = .030$). The remaining comparisons were not statistically significant. Consequently, it would be inappropriate to describe pseudophakic participants as having statistically superior visual performance across the entire defocus curve.

This distinction strengthens the interpretation of the study. Rather than demonstrating a categorical difference between the two populations, the defocus data suggest that both populations benefited from a broad range of functional vision, with relatively small between-group differences.

The findings are compatible with previous investigations of simultaneous-vision and extended-depth-of-focus contact lenses. Madrid-Costa *et al*., (2013) demonstrated useful visual performance over multiple defocus levels with simultaneous-vision multifocal lenses, while Kim *et al*., (2024) reported improved intermediate vision with a refractive multifocal contact lens. Kamiya *et al*., (2025) similarly demonstrated favourable distance-to-near visual performance using an extended-depth-of-focus contact-lens design. The more recent comparative work of Martínez-Plaza *et al*., (2025) further emphasizes that visual performance varies among contemporary centre-near MFCL designs, highlighting the importance of optical design when interpreting defocus curves.

In pseudophakic patients, the present results are particularly relevant because loss of accommodation following monofocal IOL implantation leaves patients dependent on an external optical solution for intermediate and near tasks. Miyata *et al*., (2020) demonstrated that MFCLs can provide useful near and intermediate vision in patients with monofocal IOLs, supporting the present observation that postoperative pseudophakic eyes can achieve a clinically useful range of vision with an external multifocal correction.

From a functional perspective, intermediate vision is increasingly important because modern visual demands frequently involve distances between approximately 40 and 100 cm, including computer use, tablet viewing, mobile-phone interaction, cooking, shopping, reading labels, and household activities. Therefore, the ability of MFCLs to extend functional vision across the intermediate range may be as clinically relevant as improvement in conventional near visual acuity.

Near Visual Acuity

Near visual acuity showed one of the most pronounced improvements following MFCL fitting. The presbyopic group improved from 0.287 ± 0.106 logMAR to 0.1205 ± 0.0144 logMAR, while the pseudophakic group improved from 0.384 ± 0.0694 to 0.113 ± 0.0091 logMAR. Both improvements were statistically significant ($p < .001$).

The magnitude of improvement is clinically meaningful because near vision is the primary functional deficit associated with presbyopia and is also a major limitation following monofocal IOL implantation. The improvement in pseudophakic participants is particularly relevant because these patients may have excellent distance vision yet remain substantially dependent on reading spectacles.

The present results are consistent with Kim *et al*., (2024), who reported significant improvement in near visual acuity with a refractive MFCL while maintaining good distance and intermediate performance. Similar findings have been reported with other simultaneous-vision designs (Madrid-Costa *et al*., 2013; Kazancı *et al*., 2022) and with newer extended-depth-of-focus contact-lens technology (Kamiya *et al*., 2025).

The pseudophakic findings are particularly consistent with Miyata *et al*., (2020), who demonstrated that multifocal soft contact lenses can improve near vision in patients with monofocal IOLs. Kamiya *et al*., (2021) further showed that visual performance and patient satisfaction achieved with MFCLs worn over monofocal IOLs could be comparable with those achieved following multifocal IOL implantation. Together, these findings support MFCLs as a reversible postoperative strategy for patients who have satisfactory distance vision after cataract surgery but continue to experience functional near limitations.

The comparison with alternative presbyopia-correction strategies is also relevant. Richdale *et al*., (2006) demonstrated advantages of multifocal contact lenses over conventional monovision in binocular visual performance and stereopsis, despite some optical trade-offs. Parekh *et al*., (2023) similarly showed that modified monovision and multifocal strategies have different strengths, with multifocal correction providing balanced binocular performance across multiple viewing conditions. These studies support the rationale for considering MFCLs particularly in patients who prioritize binocular function and freedom from spectacle dependence.

Thus, the near-vision findings of the present study should not be interpreted merely as an improvement in a numerical logMAR value. Rather, they demonstrate that MFCLs can convert the major functional limitation of both natural presbyopia and monofocal pseudophakia into a more usable range of near vision.

Contrast Sensitivity and the Optical Trade-off

Contrast sensitivity is an essential complement to high-contrast visual acuity because a patient may achieve excellent Snellen or logMAR acuity while experiencing reduced image quality under lower-contrast conditions. This issue is particularly relevant to multifocal optics because simultaneous-vision designs distribute light among multiple focal images.

In the present study, contrast sensitivity in presbyopic participants changed minimally, from 2.03 ± 0.35 to 2.02 ± 0.41 log units, with no statistically significant difference ($p = .700$). Pseudophakic participants demonstrated a small numerical reduction from 1.97 ± 0.05 to 1.94 ± 0.11 log units.

The general pattern is consistent with previous MFCL literature. Soni *et al*., (2003) demonstrated that multifocal soft contact lenses can produce measurable changes in binocular contrast sensitivity compared with single-vision correction, illustrating the optical cost associated with simultaneous multifocal imaging. Sha *et al*., (2016) similarly reported that short-term MFCL wear may involve modest changes in visual performance and visual symptoms while maintaining satisfactory overall function.

The findings of Fogt *et al*., (2022) are particularly relevant because they showed that MFCL visual performance can be comparable with progressive addition spectacles despite differences in contrast sensitivity. This reinforces the principle that a modest reduction in one objective optical parameter does not necessarily equate to inferior overall patient experience.

The pseudophakic contrast-sensitivity result, however, requires specific caution in the present study. The source dataset reports $t = 1.068$ and $p = .002$. These values require verification against the original statistical output because the reported test statistic and p-value appear internally discordant. Accordingly, the present manuscript should not claim a statistically significant deterioration in pseudophakic contrast sensitivity until the original analysis is confirmed. The defensible interpretation at this stage is that a small numerical reduction was observed.

This issue also illustrates an important methodological point: statistical significance should not be interpreted independently of effect magnitude. The absolute difference between the pre- and post-MFCL pseudophakic means was approximately 0.03 log units. Even if statistical significance were confirmed, the clinical importance of such a small difference would need to be considered in relation to the substantial gains in near and intermediate visual function.

The present findings therefore support a balanced interpretation of the optical trade-off. MFCLs may introduce some reduction in contrast or image quality in selected circumstances, but this does not necessarily outweigh their functional advantage. The optimal lens should therefore be selected according to the patient's visual priorities rather than by maximizing a single laboratory measure.

Patient-Reported Visual Function and Satisfaction

An important strength of the present study was the inclusion of patient-reported outcomes alongside objective visual measurements. This is particularly relevant in presbyopia correction because visual acuity measured under controlled clinical conditions does not always predict how successfully a patient performs everyday visual tasks.

The present study found generally favourable patient-reported visual performance after MFCL fitting in both groups. Participants reported good performance in routine near and intermediate activities, with relatively limited difficulty across most assessed tasks. The pseudophakic group showed a tendency toward higher overall functional scores, while presbyopic participants reported somewhat greater difficulty with selected demanding near activities.

These findings complement the objective visual outcomes. The improvement in near and intermediate vision was not merely a numerical laboratory finding; it was accompanied by favourable subjective reports of daily visual performance. This convergence between objective and subjective outcomes strengthens the clinical interpretation of MFCL effectiveness.

Kim *et al*., (2024) similarly reported high satisfaction following refractive MFCL fitting, with favourable subjective performance across distance, intermediate, and near tasks. Kamiya *et al*., (2021) found that MFCL wear over monofocal IOLs could achieve patient satisfaction comparable with multifocal IOL correction, despite some differences in optical performance. Kamiya *et al*., (2025) also demonstrated favourable satisfaction with EDOF contact lenses across multiple viewing distances.

The findings are further supported by Fogt *et al*., (2022), who found that MFCL performance was broadly comparable with progressive addition spectacles and that contact lenses could offer advantages in visual freedom and convenience. Richdale *et al*., (2006) similarly demonstrated the importance of binocular performance and stereopsis in patient preference for multifocal correction over monovision.

The present study therefore reinforces an important principle of presbyopia management: successful correction should be evaluated according to functional visual needs and patient experience, not visual acuity alone.

However, the patient-reported findings require one methodological clarification before final publication. The manuscript identifies the questionnaire as NAVQ-10, whereas the detailed thesis material contains a broader collection of activity and symptom items. The final manuscript should therefore verify the exact questionnaire version, scoring system, translation process, and item structure before describing the instrument as a validated NAVQ-10 administration. This is particularly important because questionnaire validity depends on preserving the original item structure and scoring methodology.

Adaptation, Fitting, and Patient Selection

The favourable outcomes observed after only three days of MFCL wear also highlight the importance of adaptation and clinical fitting. Simultaneous-vision multifocal lenses present the visual system with multiple images, requiring the patient to adapt to a different retinal image distribution compared with conventional single-focus correction.

Papas *et al*., (2009) demonstrated the utility of short-term evaluation in presbyopic contact-lens performance, supporting the clinical value of early assessment during the adaptation process. Nevertheless, the three-day period used in the present study should not be interpreted as evidence of long-term adaptation. It demonstrates early functional performance, not sustained tolerance over months or years.

The role of individualized fitting is also important. MFCL success depends on more than nominal lens power. Centration, movement, ocular surface condition, refractive accuracy, add requirement, pupil behaviour, visual demands, and patient expectations can all influence the final outcome. Contemporary contact-lens practice therefore emphasizes systematic troubleshooting, individualized fitting, and counselling rather than simply selecting a lens from a manufacturer's fitting guide (Varshney, 2025).

Patient awareness and acceptance may also influence successful adoption. Varshney *et al*., (2024) demonstrated that knowledge and awareness influence contact-lens adoption in the general population of South Gujarat. This is relevant to MFCL practice because patients who understand the expected adaptation process and possible optical compromises may be more likely to tolerate early visual phenomena and achieve successful long-term wear.

The broader contact-lens literature also supports the importance of binocular visual function. Varshney *et al*., (2025) reported differences in binocular visual function between spectacle and soft contact-lens correction, reinforcing the importance of assessing contact-lens performance from a binocular rather than purely monocular perspective.

Why Might Pseudophakic Participants Have Performed Slightly Better?

One of the more interesting observations was the tendency for pseudophakic participants to demonstrate numerically better visual performance at several measurement points. However, the present study cannot establish a definitive mechanism for this finding.

A plausible explanation is that pseudophakic participants had a stable monofocal IOL-based distance correction before MFCL fitting. The MFCL therefore acted primarily as an additional optical strategy to extend the range of vision rather than correcting substantial baseline refractive blur. In contrast, presbyopic participants retained the natural crystalline lens and may have had greater variability in refractive status and age-related optical quality.

The difference may also reflect baseline visual status rather than an intrinsic advantage of pseudophakia. The pseudophakic group was older and had a different distribution of baseline visual acuity. Furthermore, the present study did not measure ocular aberrations, pupil size, retinal image quality, or neural adaptation, and therefore cannot determine which optical or neural factors explain the observed pattern.

The previous literature largely evaluates these populations separately rather than directly comparing them under identical conditions. Miyata *et al*., (2020) and Kamiya *et al*., (2021) provide strong evidence for MFCL utility in monofocal pseudophakia, whereas Kim *et al*., (2024), Madrid-Costa *et al*., (2013), Kazancı *et al*., (2022), and Kamiya *et al*., (2025) primarily provide evidence in presbyopic populations.

Therefore, the present study contributes a useful comparative observation, but the finding should be considered hypothesis-generating rather than definitive evidence of pseudophakic superiority.

Comparison with Other Multifocal Contact-Lens Designs

Another important consideration is that MFCLs are not a single homogeneous optical category. Centre-near, centre-distance, simultaneous-vision, segmented, refractive, and extended-depth-of-focus designs may produce different patterns of distance, intermediate, and near performance.

Madrid-Costa *et al*., (2013) demonstrated differences in visual performance between simultaneous-vision multifocal contact-lens designs. Kazancı *et al*., (2022) similarly found differences between multifocal lens designs in both objective and subjective measures. More recently, Martínez-Plaza *et al*., (2025) compared four daily centre-near MFCLs and demonstrated design-dependent differences in short-term visual performance. Kamiya *et al*., (2025) further demonstrated the potential of EDOF contact lenses to provide an extended range of functional vision.

These studies are important when interpreting the present results because the favourable outcomes observed here should primarily be attributed to the specific MFCL design and fitting protocol studied, rather than generalized to every multifocal contact lens currently available.

The findings of Durmaz Engin *et al*., (2025), although obtained in a younger myopic population and therefore not directly comparable with the present presbyopic/pseudophakic sample, also illustrate the broader importance of optical design and pupil-related optimization in multifocal contact-lens performance. Such evidence supports future investigation of individualized optical designs rather than assuming that a single MFCL strategy will provide identical outcomes across all patient groups.

Clinical Implications

The present findings have several implications for clinical practice. First, MFCLs provide a reversible and non-surgical means of extending functional vision in both naturally presbyopic and pseudophakic patients. This is particularly valuable for pseudophakic patients with monofocal IOLs who have good distance vision but remain dependent on spectacles for near and intermediate activities.

Second, the results support a patient-centred approach to MFCL selection. A patient who prioritizes reading and smartphone use may value near performance differently from a patient whose primary concern is driving or intermediate computer work. Therefore, lens selection should be guided by the individual's visual demands rather than a single target visual acuity.

Third, patient counselling remains essential. MFCL wear can involve a trade-off between expanded depth of focus and optical quality. Patients should be informed that adaptation may involve transient visual disturbances and that the final outcome depends on lens design, fit, refractive accuracy, ocular surface status, and individual visual expectations (Varshney, 2025).

Finally, the findings may be particularly relevant in settings where access to premium surgical presbyopia-correction options is limited. Evidence from South Asian and broader low- and middle-income settings indicates that economic and healthcare-access barriers remain important determinants of eye-care utilization (Bhattacharjee & Varshney, 2025; Bhattacharjee *et al*., 2026). MFCLs should not automatically be labelled “cost-effective” on the basis of the present study because no formal economic evaluation was performed. However, their reversibility and avoidance of additional intraocular surgery make them a potentially practical option where surgical alternatives are unsuitable, unavailable, or not preferred.

Strengths of the Study

The study has several strengths.

First, it directly compared presbyopic and bilateral pseudophakic participants within a single prospective clinical framework. Direct comparative evidence between these two populations remains relatively limited, particularly in the Indian setting.

Second, the study assessed visual function multidimensionally. Distance and near visual acuity were complemented by binocular defocus performance, contrast sensitivity, and patient-reported visual function. This is more clinically informative than evaluating distance acuity alone.

Third, all participants underwent a standardized examination and fitting protocol, with clinical assessments performed under consistent conditions and a defined adaptation period. This reduces variability attributable to differences in examiner technique and testing conditions.

Fourth, the study incorporated both objective and subjective outcomes. The agreement between improved visual acuity and favourable patient-reported function strengthens the clinical interpretation of the findings.

Finally, the study addresses a practical clinical problem: how to improve the functional range of vision in patients who either have natural presbyopia or remain presbyopic after monofocal IOL implantation.

Limitations

Several limitations should be considered.

First, the sample size was modest, with 20 participants in each group. Although the final sample exceeded the stated minimum requirement, the study remains underpowered for extensive subgroup analysis. Larger samples would permit evaluation of the influence of age, sex, baseline refractive error, add power, and other potential predictors of MFCL success.

Second, the study was conducted at a single centre, limiting external generalizability.

Third, the groups differed significantly in age distribution (p = .009). Age-related differences in ocular optics, visual demands, contrast sensitivity, and neural processing may therefore contribute to between-group differences. Age should consequently be considered a potential confounding factor rather than assuming that pseudophakia itself explains the observed differences.

Fourth, the adaptation period was only three days. Although this is sufficient to document early functional performance, it cannot establish long-term tolerance, discontinuation rates, lens compliance, ocular-surface complications, or sustained patient satisfaction. Longitudinal follow-up is required.

Fifth, only one MFCL optical design was evaluated. The findings therefore cannot be generalized to all MFCLs, particularly EDOF, centre-distance, or alternative simultaneous-vision designs.

Sixth, advanced optical measurements such as wavefront aberrometry, higher-order aberrations, retinal image-quality metrics, straylight, modulation transfer function, and pupillometry were not performed. Their inclusion could help explain individual differences in performance.

Seventh, ocular-surface parameters and contact-lens comfort were not evaluated comprehensively. Because tear-film stability and ocular-surface quality can influence both visual quality and tolerance, future studies should incorporate standardized ocular-surface assessments.

Eighth, the patient-reported outcome instrument requires verification. The manuscript currently refers to NAVQ-10, but the detailed thesis material contains a broader set of questionnaire items. The instrument name, version, translation methodology, scoring, and psychometric analysis should therefore be reconciled before publication.

Finally, two source-level data/statistical issues require resolution. The reported pseudophakic contrast-sensitivity analysis contains an internally questionable t/p combination, and some categorical visual-acuity distributions require reconciliation with the original dataset. These should be corrected from the raw statistical output before submission rather than being inferred from the manuscript.

Future Research

Future studies should use larger multicentre samples and longer follow-up periods to determine whether the favourable visual outcomes observed in the present study remain stable over time. Randomized comparative studies against progressive addition spectacles, monovision, EDOF contact lenses, and other presbyopia-correction approaches would provide stronger evidence regarding comparative effectiveness.

Further research should also investigate predictors of successful MFCL wear, including age, pupil size, refractive error, add power, ocular aberrations, tear-film quality, lens centration, and individual visual demands. Such work could support more individualized lens selection.

Comparative studies involving different optical designs are particularly important because contemporary MFCLs differ substantially in their distribution of distance, intermediate, and near power (Kazancı *et al*., 2022; Martínez-Plaza *et al*., 2025; Kamiya *et al*., 2025).

Future studies should also incorporate validated patient-reported outcome measures and formal psychometric evaluation. This would help determine whether small objective changes in contrast sensitivity or visual acuity translate into meaningful changes in quality of life.

Finally, economic and quality-of-life evaluations would be valuable. In populations facing barriers to advanced surgical eye care, such studies could determine the practical role of MFCLs within broader presbyopia-management pathways (Bhattacharjee & Varshney, 2025; Bhattacharjee *et al*., 2026).

Overall Interpretation

The present study provides evidence that MFCLs can substantially improve functional vision in both naturally presbyopic and bilateral pseudophakic patients with monofocal IOLs. The most consistent benefit was improvement in near vision, while the binocular defocus curve demonstrated that the benefit extended beyond a single near endpoint to encompass a broader range of intermediate and near viewing demands.

The findings also demonstrate that successful MFCL correction involves a balance between visual range and optical quality. Contrast sensitivity was largely preserved in the presbyopic group, while the pseudophakic group showed a small numerical reduction that requires statistical verification. Importantly, this potential optical trade-off occurred alongside favourable patient-reported visual function.

Although pseudophakic participants demonstrated numerically better performance across several outcomes, the evidence does not support a blanket conclusion that pseudophakic patients have superior MFCL outcomes. Rather, both groups achieved clinically useful multifocal vision, and the observed between-group differences were generally modest.

The broader clinical implication is therefore that MFCLs should be considered a flexible, reversible, patient-centred option for presbyopia management in both naturally presbyopic and pseudophakic populations, provided that lens design, fitting, ocular health, visual demands, and patient expectations are carefully considered.

5. CONCLUSION

Multifocal contact lenses demonstrated significant improvements in binocular distance, intermediate, and near visual acuity in both presbyopic individuals and bilateral pseudophakic patients implanted with monofocal intraocular lenses. The binocular defocus curve confirmed an extended range of functional vision, while contrast sensitivity remained within clinically acceptable limits despite the expected optical trade-off associated with simultaneous-vision lens designs. Furthermore, high levels of patient satisfaction and favourable NAVQ-10 outcomes indicated that these objective improvements translated into meaningful benefits during everyday visual activities.

Importantly, comparable visual outcomes were observed between presbyopic and pseudophakic participants, suggesting that MFCLs provide an effective non-surgical strategy for restoring functional vision irrespective of the underlying mechanism of accommodative loss. These findings support the use of MFCLs not only as a primary option for presbyopia correction but also as an effective postoperative visual rehabilitation strategy for pseudophakic patients who continue to experience near and intermediate visual limitations after monofocal intraocular lens implantation.

The comprehensive evaluation of objective visual performance and patient-reported outcomes presented in this study contributes to the growing evidence supporting MFCLs as a safe, effective, and patient-centred approach to presbyopia management. With appropriate patient selection, individualized fitting, and adequate counselling, MFCLs have the potential to improve functional vision, reduce spectacle dependence, and enhance quality of life across a broad spectrum of presbyopic and pseudophakic patients. Further multicentre, longitudinal studies with larger sample sizes and comparisons across different lens designs are warranted to validate these findings and optimize clinical recommendations for multifocal contact lens use.

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