RESEARCH PAPER

Balancing Visual Performance and Monovision Optical Quality after Cataract Surgery: A Systematic Review

Nurul Fitrawati Ridwan[1], Hamzah[1], Muhammad Abrar Ismail[1, 2], Andi Akhmad Faisal[1, 2] and Sultan Hasanuddin[1, 2]

[1]Department of Ophthalmology, Faculty of Medicine, Hasanuddin University, Makassar, Indonesia
[2]Hasanuddin University Hospital, Makassar, Indonesia
***Corresponding:** nurulfitrawatiridwan@gmail.com*
Jl. Perintis Kemerdekaan Km.10, Tamalanrea, Makassar, Indonesia, 90245

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ABSTRACT

Background: Cataract surgery has evolved into a refractive procedure aiming to optimize visual performance and reduce spectacle dependence. Monovision has emerged as an alternative strategy to multifocal and extended depth-of-focus (EDOF) intraocular lenses, potentially offering a balance between functional vision and optical quality.

Objective: To systematically evaluate the effectiveness of monovision after cataract surgery in terms of visual performance and optical quality.

Methods: This study applied a systematic review approach guided by PRISMA, utilizing PubMed, ScienceDirect, and SpringerLink using the keywords “visual acuity”, “monovision”, and “cataract surgery”. Studies published in the last 10 years, written in English, and reporting outcomes related to visual acuity, spectacle independence, contrast sensitivity, or optical phenomena were included. Altogether, nine studies complied with the inclusion standards and were analyzed qualitatively.

Results: Functional near and intermediate vision, together with good unaided distance visual acuity, was demonstrated by monovision, especially within mini-monovision strategies. Spectacle independence was reported at high rates, most notably for distance and intermediate tasks. When compared to multifocal IOLs, fewer optical disturbances such as halos and glare were identified, alongside improved preservation of contrast sensitivity. However, reduced stereopsis was observed, particularly with higher degrees of anisometropia.

Conclusion: Monovision provides a favorable balance between visual performance and optical quality after cataract surgery. Mini-monovision appears to offer optimal outcomes by enhancing functional vision while minimizing optical disturbances.

Keywords: *Cataract Surgery; Monovision; Visual Acuity; Contrast Sensitivity; Intraocular Lenses*

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INTRODUCTION

Cataract surgery has been refined from a purely sight-restoring procedure into a refractive intervention aimed at optimizing postoperative visual function and reducing dependence on spectacles. With increasing patient expectations, modern cataract surgery emphasizes not only visual acuity but also overall visual performance, including intermediate and near vision, contrast sensitivity, and visual quality under varying lighting conditions.[1] Advances in IOL design, such as multifocal and extended depth-of-focus lenses, have further enhanced functional vision across multiple distances.[2]

Even with these advances, achieving a desirable balance between visual performance and optical quality remains challenging. Premium IOLs can improve visual range but are often associated with visual disturbances like glare, halos, and a reduction in contrast sensitivity, potentially affecting patient satisfaction.[3] Dysphotopsia has also emerged as a significant postoperative issue, impacting perceived visual quality even in patients with good visual acuity.[4] Therefore, selecting an appropriate presbyopia correction strategy requires careful consideration of both functional outcomes and optical side effects.

Monovision has emerged as a practical alternative, utilizing anisometropia to enable vision at multiple distances by correcting one eye for distance and the fellow

**Author for Correspondence: nurulfitrawatiridwan@gmail.com*

eye for near or intermediate vision. This approach is widely used due to its simplicity, cost-effectiveness, and fewer photic disturbances compared with multifocal IOLs.[5] Additionally, monovision with monofocal IOLs preserves contrast sensitivity and reduces optical disturbances while still providing a degree of spectacle independence.[1]

However, the effectiveness of monovision depends on several factors, including the degree of anisometropia, neuroadaptation, ocular dominance, and binocular visual function. While it improves functional vision, it may reduce stereopsis and depth perception.[5] Variations such as mini-monovision further complicate refractive targeting but may offer a better balance between visual performance and binocular function.[2]

Recent studies have expanded surgical outcome measures beyond visual acuity to include patient-reported outcomes, spectacle independence, and real-world visual function.[6] However, variability in study designs and outcome assessments has led to inconsistent findings, and no clear consensus exists regarding the optimal role of monovision compared to advanced IOL technologies.[7]

Based on this background, this study aims to systematically review current evidence on monovision, emphasising its impact on distance-specific visual acuity and independence from spectacles, contrast sensitivity, and optical phenomena, to better understand its clinical benefits and limitations.

METHODS

Study Design

This systematic review, performed following PRISMA standards, sought to examine the balance between visual performance and optical quality of monovision post-cataract surgery. The review focused on key clinical outcomes, including visual acuity at multiple distances, spectacle independence, contrast sensitivity, and optical phenomena such as glare and dysphotopsia.

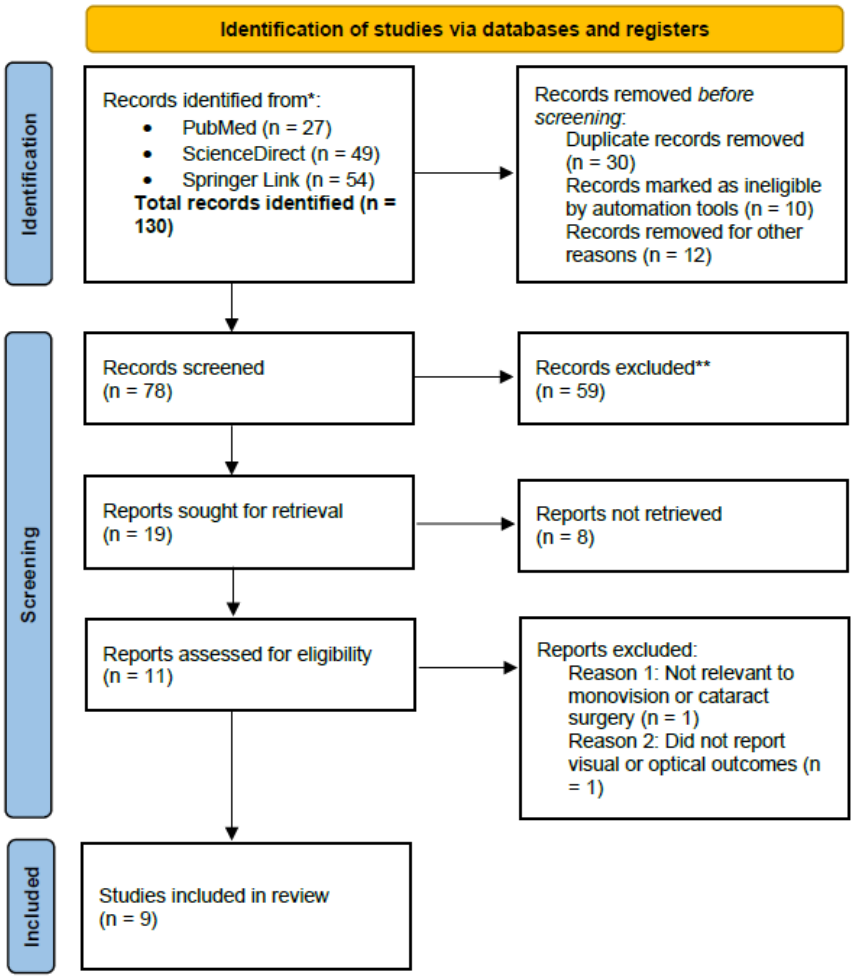

Figure 1. Prisma Flowchart

Search Strategy

A structured search of the literature was undertaken across three major electronic sources, namely PubMed, ScienceDirect, and SpringerLink. The retrieval process was guided by a set of selected terms, such as "visual acuity", "monovision", and "cataract surgery", which were

systematically combined through Boolean logic (AND) to refine the results. Only publications from the preceding decade and written in English were considered eligible for inclusion. Furthermore, to ensure completeness, the reference lists of pertinent studies were carefully examined in order to capture any additional relevant publications that may not have been identified through the initial database search.

Eligibility Criteria

Studies were deemed suitable for inclusion when they fulfilled several predefined conditions. Firstly, eligible research designs encompassed randomised controlled trials, as well as prospective, retrospective cohort, and cross-sectional investigations. Secondly, the study population consisted of individuals who had undergone cataract extraction utilising monovision or mini-monovision approaches. Thirdly, the intervention involved the application of either monofocal intraocular lenses or extended depth-of-focus lenses within a monovision strategy. Finally, included studies were required to report at least one relevant outcome measure, such as visual acuity at distance, intermediate, or near ranges, degree of spectacle independence, contrast sensitivity, or the presence of optical disturbances, including glare. Conversely studies were excluded if full-text access was unavailable, if the publication was not presented in English, or if the outcomes assessed did not pertain to visual performance or optical quality in the context of monovision.

Study Selection

Study selection adhered to the PRISMA framework. Records were initially retrieved from PubMed (n=27), ScienceDirect (n=49), and SpringerLink (n=54). Following deduplication, titles and abstracts were screened for relevance. Ineligible studies were excluded, and full texts subsequently assessed. Ultimately, nine studies were retained for qualitative synthesis.

Bias Assessment

Risk of bias evaluation was conducted using design-specific instruments. Randomised controlled trials were appraised with the Cochrane ROB 2 framework, whereas observational studies were examined using the NOS, ensuring methodological quality was systematically and consistently assessed. This approach ensured a structured and reliable evaluation of methodological quality across included studies.

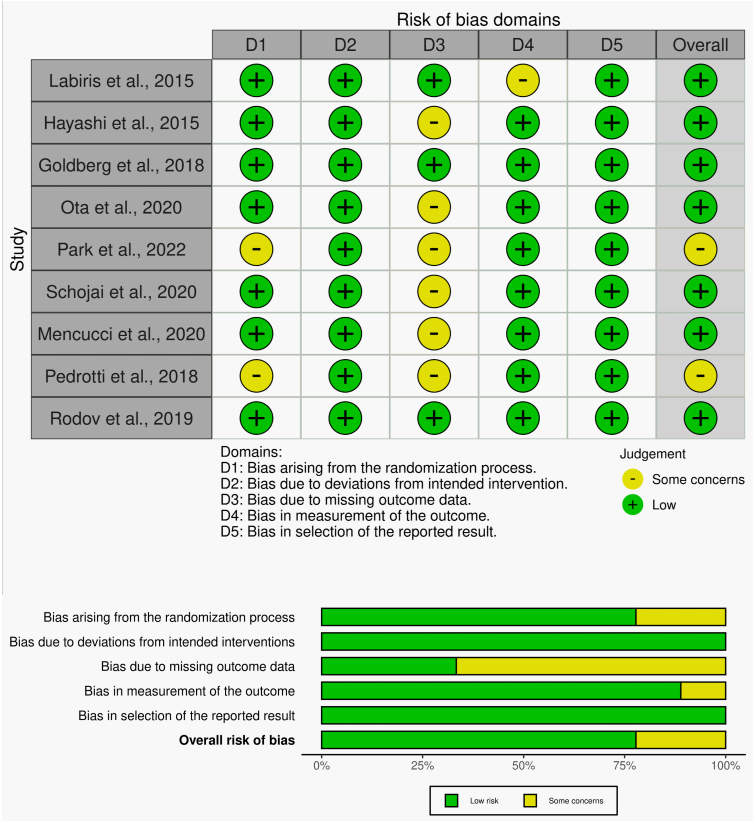

Figure 2. ROB2 bias assessment results.

Data Extraction

Data were systematically extracted using a predefined template, capturing key study characteristics including author, publication year, design, sample size, intraocular lens type, anisometropia level, and follow-up period. Outcomes were classified as primary (UDVA, UIVA, UNVA) and secondary, encompassing spectacle independence, contrast sensitivity, and photic phenomena such as glare and halos. To ensure consistency, outcome measures were standardized where possible, with visual acuity assessed using clinical metrics and subjective outcomes evaluated through questionnaire-based reports,

allowing integration of objective and patient-reported data into a unified analysis.

Table 1. Summary of Included Studies on Monovision after Cataract Surgery

No	Study (Author, Year)	Design	Sample	Intervention / Strategy	Follow-up	Visual Performance	Spectacle Independence	Optical Quality / Phenomena
1	Finkelman et al., 2009	Prospective study	82 pts	Pseudophakic monovision (monofocal IOL)	6 months	Good UDVA, functional near vision	High	Minimal glare/halo
2	Ito et al., 2009	Clinical study	40 pts	Monovision with monofocal IOL	3 months	Good binocular VA, reduced stereopsis	Moderate	Reduced contrast sensitivity
3	Zhang et al., 2011	Comparative study	60 pts	Monovision vs multifocal IOL	6 months	Comparable distance VA, lower near VA vs MIOL	Moderate–High	Fewer halos vs MIOL
4	Iida et al., 2011	Comparative study	50 pts	Hybrid monovision (mono + multifocal)	6 months	Improved intermediate & near VA	High	Mild optical disturbance
5	Hayashi et al., 2015	Prospective observational	82 pts	Conventional vs modified monovision	3 months	Better UIVA/UNVA in modified group	Moderate	Preserved contrast sensitivity
6	Labiris et al., 2015	RCT	75 pts	Mini-monovision vs multifocal IOL	6 months	Comparable VA, better tolerance in monovision	High	Lower glare/halo vs MIOL
7	Goldberg et al., 2018	Prospective cohort	56 pts	Mini-monovision (-1.25 to -1.50 D)	6 months	Good VA at all distances	High	Minimal optical symptoms
8	Ota et al., 2020	Prospective comparative	64 pts	EDOF with mini-monovision (-0.5 D)	3 months	Improved intermediate vision	High	Mild photic phenomena
9	Park et al., 2022	Retrospective study	50 pts	Mini-monovision with enhanced monofocal IOL	3 months	Good UDVA, UIVA, UNVA	High	Low incidence glare/halo

Quality Assessment

Methodological rigour of included studies was appraised using the 2011 Oxford Centre for Evidence-Based Medicine Levels of Evidence. Each study was graded by evidence hierarchy, from randomised trials to observational designs and case series. This framework enabled a systematic evaluation of the overall strength and credibility of the evidence.

Operational Definitions

Monovision was described as a refractive approach whereby the dominant eye is corrected for distance and the fellow, non-dominant eye for near tasks, typically with an interocular difference of approximately −1.25 to −2.00 dioptres. Mini-monovision referred to a modified strategy employing a reduced level of anisometropia, generally between −0.25 and −0.75 dioptres, designed to improve

intermediate and near vision while preserving binocular visual function and patient comfort.

Data Synthesis

Owing to variability in study designs, intraocular lens types, levels of anisometropia, and outcome measures, quantitative meta-analysis was not undertaken. Instead, a qualitative synthesis was employed. Findings were examined descriptively to identify trends and distinctions in visual performance and optical quality, with particular attention to clinical trade-offs associated with monovision following cataract surgery.

RESULTS

Nine studies were ultimately incorporated into this systematic review, representing diverse methodological approaches, including randomised controlled trials, prospective cohorts, and observational designs. These investigations assessed a range of monovision techniques utilising monofocal, enhanced monofocal, and extended depth-of-focus intraocular lenses, with follow-up periods spanning three to six months. Primary outcomes focused on visual performance across distances and optical quality, encompassing spectacle independence, contrast sensitivity, and photic phenomena.

Visual Performance Outcomes

Monovision demonstrated favorable visual performance across multiple distances. Most studies consistently reported good uncorrected distance visual acuity (UDVA), reflecting the effectiveness of targeting the dominant eye for distance vision. Functional near vision was also achieved through the induction of mild to moderate anisometropia in the non-dominant eye, particularly in mini-monovision approaches ranging from −0.50 to −1.50 diopters. Several studies highlighted that intermediate visual acuity (UIVA) was notably improved in mini-monovision and EDOF-based monovision strategies, suggesting that smaller degrees of anisometropia may offer a more balanced visual outcome across distances. Comparative studies indicated that while multifocal intraocular lenses may provide superior near visual acuity, monovision achieves comparable distance vision with acceptable near and intermediate performance. Importantly, modified or mini-monovision strategies demonstrated improved binocular visual function compared to conventional monovision, suggesting that reduced anisometropia may enhance overall visual performance without significantly compromising near vision. However, some studies reported a reduction in stereopsis associated with monovision, indicating a trade-off between binocular depth perception and functional vision.

Spectacle Independence

Spectacle independence was consistently reported as one of the main advantages of monovision. Across the included studies, a high proportion of patients achieved independence from spectacles for most daily activities, particularly in mini-monovision groups. Studies utilizing enhanced monofocal and EDOF lenses in combination with monovision strategies reported even higher rates of spectacle independence, especially for intermediate tasks such as computer use. Comparative analyses suggested that while multifocal IOLs may provide slightly higher complete spectacle independence, monovision offers a favorable balance between reduced dependence on spectacles and fewer visual disturbances. The degree of anisometropia appeared to play a crucial role, with moderate levels (approximately −0.75 to −1.50 diopters) providing optimal outcomes in terms of functional independence and patient satisfaction.

Optical Quality and Visual Disturbances

Optical quality outcomes favored monovision over multifocal IOL strategies in several aspects. Studies consistently reported a lower incidence of photic phenomena, such as glare and halos, in monovision patients. This is attributed to the absence of light-splitting optics, which are commonly associated with multifocal lenses. As a result, monovision was associated with better tolerance in low-light conditions and fewer complaints related to night vision disturbances. Contrast sensitivity was generally preserved in monovision approaches, particularly when monofocal IOLs were used. However, some studies noted a mild reduction in contrast sensitivity and binocular visual quality due to anisometropia, especially in conventional monovision with higher refractive differences. In contrast, mini-monovision strategies appeared to maintain better optical quality while still providing functional vision across distances. Although optical phenomena were less frequent compared to multifocal or EDOF IOLs, mild visual disturbances were still reported in some patients, particularly in hybrid or EDOF-based monovision approaches. These findings suggest that while monovision reduces the risk of dysphotopsia, it does not completely eliminate optical side effects.

Overall Balance Between Visual Performance and Optical Quality

The synthesis of included studies indicates that monovision provides a clinically effective balance between visual performance and optical quality after cataract surgery. While it may not achieve the same level of near visual acuity as multifocal IOLs, monovision offers stable distance vision, functional intermediate and near vision, and a lower incidence of disturbing optical phenomena. Mini-monovision, in particular, appears to represent an optimal compromise, as it enhances intermediate vision and maintains binocular function while minimizing optical disturbances. The findings suggest that monovision remains a relevant and effective strategy in modern cataract surgery, particularly for patients prioritizing visual quality and reduced risk of photic phenomena over complete spectacle independence.

DISCUSSION

Concept of Monovision and Anisometropia

Monovision is based on the principle of inducing anisometropia, where one eye is corrected for distance vision while the fellow eye is targeted for near or intermediate vision, allowing functional vision across multiple focal distances without complete reliance on multifocal optics.[8] The effectiveness of this strategy depends on the degree of anisometropia, as excessive refractive difference may impair binocular function, while insufficient anisometropia may fail to provide adequate near vision.[9] Studies have suggested that an optimal anisometropic range of approximately −1.00 to −1.50 diopters provides a balance between distance clarity and near visual function while maintaining patient tolerance.[10] Furthermore, modified monovision approaches with lower anisometropia, such as mini-monovision, have been shown to improve intermediate vision while preserving binocular visual performance, making them increasingly favored in modern cataract surgery.[11]

Spectacle Independence and Patient Satisfaction

Monovision has consistently demonstrated a high rate of spectacle independence, particularly for distance and intermediate activities, making it an attractive alternative to multifocal intraocular lenses.[8] Comparative studies indicate that while multifocal IOLs may achieve slightly higher complete spectacle independence, monovision offers a more stable visual experience with fewer optical disturbances, contributing to high patient satisfaction.[12] Mini-monovision strategies further enhance patient-reported outcomes by providing a more natural visual transition between distances and improved comfort in daily activities.[13] In large cohort studies, patients undergoing mini-monovision reported high satisfaction rates and reduced dependence on spectacles, particularly for intermediate tasks such as computer use.[14] Additionally, comparisons between different IOL technologies suggest that monovision remains competitive with advanced lens designs in terms of patient satisfaction, especially when visual quality is prioritized over complete spectacle independence.[15] Recent observational studies using enhanced monofocal IOLs combined with monovision have reported further improvements in functional vision and patient satisfaction, reinforcing its role as a cost-effective and well-tolerated approach.[16]

Stereoacuity, Binocular Function, and Contrast Sensitivity

Despite its advantages, monovision introduces alterations in binocular vision due to induced anisometropia, which may reduce stereopsis and depth perception.[9] The degree of binocular disruption is closely related to the magnitude of anisometropia, with higher refractive differences leading to greater impairment in stereoacuity.[17] However, modified monovision strategies with reduced anisometropia have been shown to preserve binocular visual function more effectively while maintaining acceptable near vision.[11] Comparative studies evaluating crossed versus conventional monovision have demonstrated that binocular visual outcomes may vary depending on ocular dominance and adaptation mechanisms.[18] Similarly, differences in binocular performance between conventional and modified monovision approaches highlight the importance of individualized patient selection and refractive targeting.[19] In terms of contrast sensitivity, monovision generally preserves optical quality better than multifocal IOLs due to the absence of light-splitting optics, although slight reductions may still occur in cases with higher anisometropia.[17]

Spectacle Independence Comparison Between Multifocal, EDOF, and Enhanced Monofocal IOLs

When compared with multifocal and EDOF intraocular lenses, monovision demonstrates distinct advantages and limitations. Multifocal IOLs provide superior near visual acuity but are often associated with increased optical disturbances, whereas monovision offers more stable distance vision with fewer photic phenomena.[12] Randomized trials have shown that although multifocal lenses achieve higher spectacle independence, monovision provides comparable functional vision with better tolerance and fewer visual complaints.[20] Mini-monovision has also been directly compared with multifocal IOLs, demonstrating similar visual outcomes with reduced incidence of glare and halos.[13] Advances in IOL technology, including EDOF lenses, have further expanded the options for presbyopia correction, with studies showing improved intermediate vision when combined with mild monovision strategies.[1] Comparative analyses between trifocal, EDOF, and monovision approaches indicate that while premium IOLs offer extended range of vision, monovision remains advantageous in terms of visual quality and reduced optical disturbances.[15] Prospective studies evaluating EDOF lenses with mini-monovision have demonstrated enhanced intermediate visual acuity without significantly compromising distance vision.[21] Additional comparative studies confirm that both EDOF and enhanced monofocal IOLs can benefit from monovision strategies, particularly in achieving a balance between visual performance and optical quality.[22] Enhanced monofocal IOLs have also been shown to improve intermediate vision while maintaining high contrast sensitivity, making them suitable for mini-monovision applications.[23] Furthermore, systematic reviews and network meta-analyses indicate that no single IOL strategy is universally superior, highlighting the importance of individualized treatment selection.[7]

Optical Phenomena, Dysphotopsia, and Visual Disturbances

Optical quality is a critical factor influencing patient satisfaction after cataract surgery, particularly in relation to photic phenomena such as glare, halos, and dysphotopsia.[3] Monovision is generally associated with a lower incidence of these visual disturbances compared to multifocal IOLs, as it does not rely on diffractive or refractive light-splitting mechanisms.[24] Dysphotopsia remains a concern in cataract surgery overall, but its

occurrence is less pronounced in monovision strategies using monofocal lenses.[25] Recent studies have emphasized that unwanted visual phenomena can still occur even with advanced IOL designs, underscoring the importance of considering optical quality alongside visual acuity outcomes.[4] Moreover, broader evaluations of postoperative outcomes highlight that visual quality extends beyond acuity, incorporating contrast sensitivity, glare tolerance, and patient-reported visual disturbances as key determinants of success.[6] These findings reinforce that monovision provides a favorable balance between functional vision and optical quality, particularly for patients seeking to minimize visual disturbances while maintaining satisfactory visual performance.

CONCLUSION

Monovision is a clinically effective and balanced strategy for presbyopia correction after cataract surgery, providing good uncorrected distance vision with functional near and intermediate performance while maintaining favorable optical quality. Compared with multifocal and extended depth-of-focus intraocular lenses, it is associated with fewer photic disturbances and better contrast sensitivity, although some reduction in stereopsis may occur. The use of mini-monovision with lower anisometropia further optimizes outcomes by improving intermediate vision while minimizing optical side effects. Overall, monovision remains a cost-effective and well-tolerated option, particularly for patients who prioritize visual quality and reduced dysphotopsia.

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Ethical Approval

Ethical approval was deemed unnecessary, as this study is based on a systematic review of previously published data.

Conflict of Interest

The authors declare that there are no conflicts of interest related to this study.

Author Contributions

All authors were involved in the conception and design of the study. The first author undertook material preparation, data collection, and analysis. All authors reviewed and approved the final manuscript.

Data Availability Statement

All data generated or analyzed during this study are included in this published article.

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