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Original Article

Multifocal intraocular lenses improve near vision but increase optical aberrations in patients with non-proliferative diabetic retinopathy

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Abstract: Objective: To evaluate the long-term effects of phacoemulsification with monofocal (SIOL) versus multifocal intraocular lens (MIOL) implantation on visual quality in patients with non-proliferative diabetic retinopathy (NPDR). Methods: A retrospective analysis was performed on 138 NPDR patients who underwent cataract surgery at the First People's Hospital of Xianyang between August 2021 and August 2023. Patients were assigned to either the SIOL group (n=62) or the MIOL group (n=76). Two years postoperatively, visual outcomes were assessed, including uncorrected and corrected visual acuity (LogMAR), spherical equivalent (SE), defocus curves, visual quality indicators (NEI VFQ-25 scores, higher-order aberrations [HOAs], contrast sensitivity), and complication rates. Multivariate logistic regression was performed to identify independent predictors of visual quality. Results: The MIOL group showed significantly better uncorrected near and intermediate visual acuity than the SIOL group (both $P < 0.05$), with no significant differences in uncorrected or corrected distance visual acuity or SE between groups (both $P > 0.05$). The MIOL defocus curve revealed a broad functional range from 0.0 D to -3.0 D, whereas the SIOL curve declined sharply after 0.0 D. MIOL recipients also had significantly lower HOAs and higher visual quality scores ($P < 0.05$). Contrast sensitivity and complication rates were comparable between groups (both $P > 0.05$). Logistic regression identified diabetes duration, total HOAs, IOL type, and complications as independent predictors of postoperative visual quality. Conclusion: MIOL implantation offers superior near and intermediate vision and overall visual quality compared to SIOLs in patients with NPDR. However, increased higher-order aberrations in some cases may affect visual function. Key determinants of visual outcomes include the duration of diabetes, IOL type, and postoperative complications.

Keywords: Non-proliferative diabetic retinopathy, posterior subcapsular cataract, phacoemulsification, monofocal intraocular lens, multifocal intraocular lens

Introduction

Non-proliferative diabetic retinopathy (NPDR), the early stage of diabetic retinopathy (DR), is characterized by microvascular abnormalities in the retinal capillaries that can impair visual function to varying degrees [1, 2]. With the rising prevalence of diabetes, the incidence of NPDR accompanied by posterior subcapsular cataracts has also increased significantly [2]. In such cases, cataract surgery not only restores visual acuity but also enhances overall quality of life. However, diabetes-associated retinal pathology can limit postoperative visual recovery, underscoring the need to optimize surgical techniques and intraocular lens (IOL) selection.

Phacoemulsification with IOL implantation is the standard procedure in modern cataract surgery and has been adapted for diabetic patients. Nonetheless, due to specific ocular changes in these individuals - such as a higher rate of posterior capsular opacification and an increased risk of retinal complications - postoperative outcomes are often variable [3, 4]. The choice of IOL plays a crucial role in determining postoperative visual function. Monofocal IOLs (SIOLs) provide stable image quality and are suitable

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for most patients; however, they are limited to a single focal point and do not address intermediate or near vision needs [5]. In contrast, multifocal IOLs (MIOLs) offer multiple focal zones, improving vision at various distances - particularly intermediate and near - but may lead to photic phenomena such as glare and halos [6, 7]. Therefore, selecting an appropriate IOL type in NPDR patients remains a key clinical challenge.

Optimizing postoperative visual quality in NPDR patients is of both scientific and clinical significance. These patients often expect more than restored distance vision - they seek long-term visual stability and functional improvement in daily life. Yet, due to the more complex retinal status in NPDR, visual recovery is typically less predictable than in the general cataract population [8, 9]. Comparing long-term visual outcomes between monofocal and multifocal IOLs in NPDR patients may provide evidence-based guidance for personalized surgical planning and postoperative rehabilitation. This study aims to evaluate and compare long-term visual performance and quality in NPDR patients receiving either monofocal or multifocal IOLs, with a focus on delineating the differences in postoperative outcomes between the two lens types.

Materials and methods

Study subjects

A total of 138 NPDR patients who underwent cataract surgery at the First People's Hospital of Xianyang between August 2021 and August 2023 were retrospectively included. The study was approved by the hospital's ethics committee. Patient demographics, medical history, clinical data, and surgical records were retrieved from the Hospital Information System (HIS) and Electronic Medical Record (EMR) system. Based on the type of IOLs implanted, patients were allocated to either the MIOL group (n=76, 103 eyes) or the SIOL group (n=62, 82 eyes).

Inclusion and exclusion criteria

Inclusion criteria: (1) Diagnosed with NPDR combined with posterior subcapsular cataract and underwent bilateral phacoemulsification. (2) Age ≥ 50 years. (3) No severe preoperative ocular comorbidities (e.g., ocular infection, advanced glaucoma, retinal detachment, or severe fundus disease). (4) No systemic disorders associated with ocular complications (e.g., severe cardiovascular, hepatic, or renal disease); diabetes was well-controlled (HbA1c < 9%). (5) Minimum of 2 years postoperative follow-up with complete and reliable medical records.

Exclusion criteria: (1) Presence of other severe ocular or extraocular complications (e.g., ocular trauma, keratitis, or glaucoma. (2) Preexisting advanced retinal conditions requiring retinal treatment (e.g., proliferative DR or retinal vascular occlusion). (3) Pregnant or lactating women, or patients with poorly controlled diabetes. (4) Known allergy to medications or procedures used in this study.

Surgical procedures

All patients underwent phacoemulsification for posterior subcapsular cataract, followed by IOL implantation.

Preoperative preparation: Comprehensive ophthalmologic assessments, including slit-lamp biomicroscopy, fundus examination, intraocular pressure measurement, autorefractometry, and A/B scans, were conducted. Patients fasted for 12 hours and received prophylactic antibiotic eye drops.

Surgical technique: Under peribulbar anesthesia, a corneal limbal incision (2.2 mm or 3.2 mm) was made based on preoperative assessment. Phacoemulsification was used to emulsify and aspirate the cataract while preserving intraocular structures. MIOLs were implanted in the MIOL group, and standard monofocal IOLs in the SIOL group.

Postoperative management: Antibiotic eye drops were continued postoperatively, and intraocular pressure was routinely monitored. All surgeries and follow-ups were performed by the same surgical team, with scheduled follow-ups extending over 2 years.

Postoperative visual function assessment

Uncorrected Visual Acuity (LogMAR): Distance, intermediate, and near uncorrected visual acuities were measured using standardized visual charts. Corrected distance visual acuity was assessed after refraction with an autorefractor.

Table 1. Comparison of preoperative baseline characteristics between MIOL and SIOL groups

Feature	MIOL group (n=76, 152 eyes)	SIOL group (n=62, 124 eyes)	X^2/t	P
Age (years)	65.29±6.98	66.13±5.57	-0.792	0.430
Gender [Male/Female, example (%)]	40/36	31/31	0.095	0.758
Diabetes duration (years)	12.03±2.18	11.94±2.63	0.226	0.821
Preoperative uncorrected visual acuity (LogMAR) (LogMAR)	0.92±0.11	0.92±0.11	-0.055	0.956
Eye length (mm)	24.62±1.15	24.81±1.27	-0.952	0.343
Intraocular pressure (mmHg)	16.21±2.27	16.04±2.22	0.432	0.667
Corneal astigmatism (D)	0.86±0.24	0.89±0.27	-0.629	0.530
Reserve diopter (D)	0.75±0.53	0.62±0.45	1.616	0.108

Note: MIOL: Multifocal Intraocular Lens, SIOL: Single-focus Intraocular Lens, LogMAR: Logarithm of the Minimum Angle of Resolution, D: Diopters.

Spherical Equivalent (SE): Refractive stability was evaluated via SE measurements using an autorefractor.

Defocus curve: Visual acuity under varying defocus levels (±0.50 D to ±4.00 D) was recorded using trial lenses to generate defocus curves, reflecting performance across distance, intermediate, and near vision.

Visual quality assessment

Visual function questionnaire (VFQ-25): The Chinese version of the National Eye Institute Visual Function Questionnaire (NEI VFQ-25) [10] was used to assess the subjective impact of vision on quality of life. Higher scores indicate better perceived visual function.

Contrast sensitivity: Measured with the CSV-1000E under photopic (85 cd/m^2) and mesopic (3 cd/m^2) conditions at spatial frequencies of 3, 6, 12, and 18 cycles/degree.

Higher-order aberrations (HOAs): Assessed using the OPD-Scan III visual quality analyzer with a 5 mm pupil diameter. Total HOAs, spherical aberration, and coma were recorded.

Statistical analysis

Data were analyzed using SPSS version 26.0. Continuous variables were expressed as mean ± standard deviation (mean ± SD) and compared using independent samples t-tests. Categorical data were presented as counts and percentages (n, %) and analyzed using chi-square or Fisher's exact test. Multivariate logistic regression was performed to identify independent predictors of postoperative visual quality. A two-sided *P*-value < 0.05 was considered statistically significant.

Results

Comparison of preoperative baseline characteristics

Bilateral surgeries were performed in 27 cases in the MIOL group and 20 cases in the SIOL group, while unilateral surgeries were performed in 49 and 42 cases, respectively. There were no significant differences in baseline characteristics between the two groups (all P > 0.05), as shown in **Table 1**.

Comparison of visual function at two years postoperatively

At the two-year follow-up, the MIOL group exhibited significantly better uncorrected intermediate and near visual acuity compared to the SIOL group (both P < 0.05). However, no significant differences were observed in uncorrected distance visual acuity, corrected distance visual acuity, or SE between the two groups (all P > 0.05), as presented in **Table 2**.

Comparison of defocus curve at two years postoperatively

At two years post-surgery, the defocus curve of the MIOL group showed peak visual acuity at 0.0 D and -3.0 D, with a broad plateau between these points, indicating a relatively smooth decline. In contrast, the SIOL group displayed a single peak at 0.0 D followed by a steep decline. The MIOL group demonstrated significantly better uncorrected visual acuity at 0.0 D and -3.0

Table 2. Comparison of visual function at 2 years postoperatively between MIOL and SIOL groups

Group	MIOL group (n=152 eyes)	SIOL group (n=124 eyes)	t	P
Uncorrected distance visual acuity (LogMAR)	0.21±0.08	0.22±0.09	-0.758	0.449
Uncorrected visual acuity (LogMAR)	0.34±0.11	0.38±0.12	-2.884	0.004
Uncorrected near visual acuity (LogMAR)	0.51±0.12	0.54±0.14	-2.188	0.03
Corrected distance vision (LogMAR)	0.11±0.06	0.12±0.07	-1.123	0.263
SE (D)	0.70±0.51	0.72±0.51	-0.471	0.638

Note: MIOL: Multifocal Intraocular Lens, SIOL: Single-focus Intraocular Lens, LogMAR: Logarithm of the Minimum Angle of Resolution, SE: Spherical Equivalent, D: Diopters.

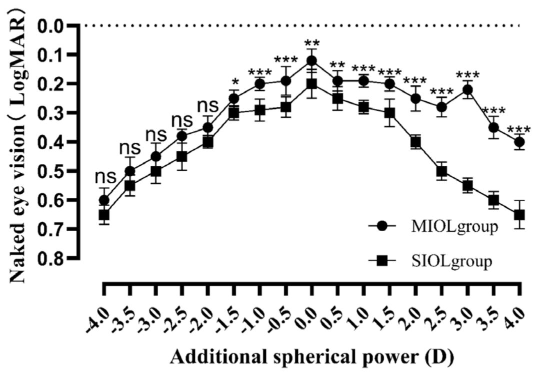

Figure 1. Comparison of defocus curve changes at 2 years postoperatively between MIOL and SIOL groups. Note: MIOL: Multifocal Intraocular Lens, SIOL: Single-focus Intraocular Lens. Compared with SIOL group, nsP > 0.05, *P < 0.05, **P < 0.01, ***P < 0.001.

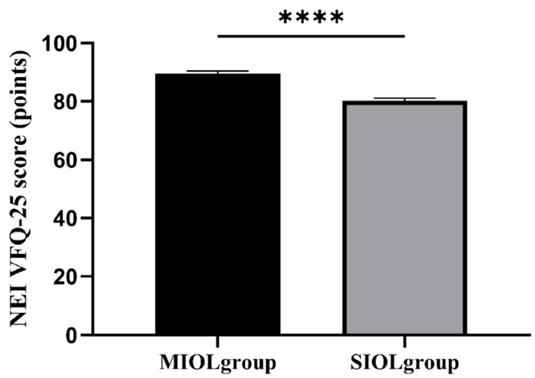

Figure 2. Comparison of visual quality scores between the two groups. Note: MIOL: Multifocal Intraocular Lens, SIOL: Single-focus Intraocular Lens; ****P < 0.0001.

D (P < 0.05), with differences at several other defocus points, as illustrated in **Figure 1**.

Comparison of visual quality at two years postoperatively

The MIOL group had a significantly higher total NEI VFQ-25 score than the SIOL group (P < 0.05), as shown in **Figure 2**. At a 5 mm pupil diameter, total HOAs, coma, and spherical aberrations were significantly lower in the MIOL group (all P < 0.05). However, the Strehl ratio was also significantly lower in the MIOL group (P < 0.05), as shown in **Table 3**. No significant differences in contrast sensitivity were observed under photopic (85 cd/m^2) or scotopic (3 cd/m^2) conditions across spatial frequencies of 3, 6, 12, and 18 cycles/degree (all P > 0.05), as presented in **Tables 4** and **5**.

Comparison of postoperative complications

Postoperative complication rates were low in both groups, with no statistically significant difference between the MIOL and SIOL groups (P > 0.05), as shown in **Table 6**.

Multivariate logistic regression analysis of factors influencing visual quality

Based on NEI VFQ-25 scores, 174 eyes were classified as having high visual quality and 102 eyes as having low visual quality. Visual quality was used as the dependent variable, with diabetes duration, total HOAs, lens type, and postoperative complications as independent variables (**Table 7**).

Univariate logistic regression revealed that each of these factors significantly affected visual quality at two years postoperatively (P < 0.05; **Table 8**). Multivariate analysis further identified diabetes duration ≥ 3 years, total HOAs ≥ 0.18, lens type (SIOL vs. MIOL), and the occurrence of complications as independent risk factors (P < 0.05), as shown in **Table 9** and **Figure 3**.

Receiver operating characteristic (ROC) curve analysis yielded an area under the curve (AUC)

Table 3. Comparison of higher-order aberrations and Strehl ratio at 2 years postoperatively between MIOL and SIOL groups

Group	MIOL group (n=152 eyes)	SIOL group (n=124 eyes)	t	P
Total HOAs (5 mm, μm)	0.54±0.16	0.29±0.11	15.682	< 0.001
Coma (5 mm, μm)	0.25±0.07	0.15±0.05	13.789	< 0.001
Spherical aberration (5 mm, μm)	0.21±0.07	0.11±0.04	13.567	< 0.001
Strehl Ratio	0.12±0.02	0.18±0.03	-18.626	< 0.001

Note: MIOL: Multifocal Intraocular Lens, SIOL: Single-focus Intraocular Lens, HOAs: Higher-Order Aberrations.

Table 4. Comparison of contrast sensitivity under photopic vision (85 cd/m^2) at different spatial frequencies between MIOL and SIOL groups

Group	MIOL group (n=152 eyes)		SIOL group (n=124 eyes)	
Glare state	No glare	Glare	No glare	Glare
3 c/d	1.85±0.11	1.65±0.13	1.82±0.10*	1.62±0.12*
6 c/d	1.70±0.12	1.50±0.14	1.66±0.11*	1.47±0.13*
12 c/d	1.55±0.13	1.35±0.15	1.51±0.12*	1.32±0.14*
18 c/d	1.40±0.14	1.20±0.16	1.36±0.13*	1.16±0.15*

Note: Compared with the MIOL group, *$P > 0.05$. MIOL: Multifocal Intraocular Lens, SIOL: Single-focus Intraocular Lens.

Table 5. Comparison of contrast sensitivity under scotopic vision (3 cd/m^2) at different spatial frequencies between MIOL and SIOL groups

Group	MIOL group (n=152 eyes)		SIOL group (n=124 eyes)	
Glare state	No glare	Glare	No glare	Glare
3 c/d	1.25±0.10	1.10±0.12	1.22±0.09*	1.07±0.11*
6 c/d	1.15±0.11	1.00±0.13	1.12±0.10*	0.95±0.12*
12 c/d	1.05±0.12	0.90±0.14	1.01±0.11*	0.86±0.13*
18 c/d	0.95±0.13	0.80±0.15	0.92±0.12*	0.78±0.14*

Note: Compared with the MIOL group, *$P > 0.05$. MIOL: Multifocal Intraocular Lens, SIOL: Single-focus Intraocular Lens.

of 0.723 (95% CI: 0.638-0.809), indicating good predictive accuracy of the model ($P < 0.05$), as shown in **Figure 4**. The regression model was constructed based on the following variables: diabetes duration ≥ 3 years, lens type (monofocal vs. multifocal IOL), and postoperative complications.

The regression equation is as follows:

Logit(P) = -0.099 (Diabetes duration ≥ 3 years) - 0.800 (lens type: SIOL) + 1.021 (Complication)

This model suggests that longer diabetes duration, use of monofocal IOLs, and the presence of complications are significant predictors of reduced postoperative visual quality in NPDR patients two years after surgery.

Discussion

NPDR represents the early stage of diabetic retinopathy and is characterized by retinal microvascular abnormalities. These vascular changes, combined with systemic metabolic dysregulation, often impair lens metabolism, contributing to the development of cataracts [11, 12]. Posterior subcapsular cataract is particularly common in diabetic patients and is associated with significant visual impairment and reduced quality of life. Phacoemulsification with IOL implantation remains the standard treatment for cataracts. However, the unique pathological and anatomical characteristics in diabetic eyes present greater challenges for visual recovery after surgery.

SIOLs are widely used due to their simple optical design and stable visual performance. However, they are limited in their ability to improve near vision. In contrast, MIOLs utilize specialized optical structures to provide enhanced vision at intermediate and near distances [13]. Despite these advantages, MIOLs may introduce drawbacks such as HOAs, glare, and reduced contrast sensitivity. Visual recovery in diabetic patients is influenced not only by lens selection but also by factors such as disease duration, postoperative complications, and ocular optical quality. Therefore, evaluating

Table 6. Comparison of postoperative complications between MIOL and SIOL groups

Index	MIOL group (n=152 eyes)	SIOL group (n=124 eyes)	P
Increased intraocular pressure after surgery	6	5	> 0.999
Post-onset cataract	9	11	0.61
Retinal detachment	1	1	> 0.999

Note: Using the Fisher's exact test, MIOL: Multifocal Intraocular Lens, SIOL: Single-focus Intraocular Lens.

Table 7. Assignment

Index	Assignment
Diabetes course	0= < 3 years; 1= ≥ 3 years
Total HOAs	0= < 0.18 μm; 1= ≥ 0.18 μm
Crystal type	0= MIOL; 1= SIOL
Complication	0= did not occur; 1= occurred

Note: MIOL: Multifocal Intraocular Lens, SIOL: Single-focus Intraocular Lens, HOAs: Higher-Order Aberrations.

the long-term impact of different IOL types on visual outcomes in NPDR patients is essential for informed surgical planning and postoperative care.

In this study, patients in the MIOL group demonstrated significantly better uncorrected intermediate and near visual acuity two years postoperatively compared to the SIOL group, while no significant difference was found in distance visual acuity. These findings highlight the benefit of MIOLs' multifocal design in enhancing visual function at varying distances. Conventional SIOLs are primarily designed to correct distance vision and offer limited support for near tasks. Diabetic patients - due to retinal microvascular damage and photoreceptor dysfunction - often have more severe deficits in near vision [14-16], making MIOLs particularly advantageous in this population. The diffractive or segmented optical design of MIOLs redistributes light across multiple focal points, enabling clearer vision across a range of distances [17, 18]. In NPDR patients, this design partially compensates for vision loss due to retinal pathology, improving functional vision in daily life. However, this design may also cause light loss and photic disturbances, especially under low-light conditions [19].

The defocus curve is a key tool for assessing the optical performance of IOLs [20]. In this study, the MIOL group exhibited a bimodal defocus curve with peaks at 0.0 D and -3.0 D and a stable plateau between them, reflecting superior visual acuity across a wide range of defocus values. Conversely, the SIOL group showed a single peak at 0.0 D followed by a steep decline, indicating limited depth of focus. These findings suggest that MIOLs provide better continuous vision across multiple distances due to their multifocal design [21].

Two years postoperatively, patients in the MIOL group also achieved higher NEI VFQ-25 scores compared to those in the SIOL group, indicating better self-reported visual function and quality of life. The NEI VFQ-25 is widely used to assess the functional impact of vision in daily life [22]. The ability of MIOLs to meet patients' needs for intermediate and near vision improves daily task performance, particularly in activities that require frequent focal transitions, such as reading or driving [23]. Diabetic patients often experience reductions in visual function due to impaired retinal microcirculation. By enhancing vision at multiple distances, MIOLs help mitigate these deficits and significantly improve quality of life [24].

Despite these advantages, MIOLs were associated with significantly higher levels of total HOAs, coma, and spherical aberrations compared to SIOLs. This is consistent with previous findings showing that the division and redistribution of light by multifocal optics may increase optical aberrations, particularly under mesopic or low-contrast conditions [25]. The MIOL group also showed a lower Strehl ratio, which suggests a compromise in retinal image quality.

No significant differences in contrast sensitivity were observed between the two groups under either photopic or scotopic conditions, suggesting comparable performance in varied lighting environments. However, patients particularly sensitive to glare or photic effects may still require additional interventions to alleviate visual discomfort caused by increased HOAs.

Postoperative complication rates were low and similar in both groups, indicating that MIOL implantation does not significantly increase surgi-

Table 8. Univariate logistic regression analysis of influencing factors affecting the visual quality score of NPDR patients two years after surgery

Index	B	S.E.	Wald	*P*	OR	95% CI for Exp (B)
Diabetes course ≥ 3 years	-0.103	0.035	8.533	0.003	0.902	0.842-0.967
Total HOAs ≥ 0.18 μm	-0.726	0.326	4.952	0.026	0.484	0.255-0.917
Crystal type	-0.800	0.327	5.972	0.015	0.449	0.236-0.853
Complication	1.099	0.471	5.437	0.020	3.000	1.191-7.554

Note: HOAs: Higher-Order Aberrations.

Table 9. Multivariate logistic regression analysis of factors influencing visual quality scores at 2 years postoperatively

Index	B	S.E.	Wald	*P*	OR	95% CI for Exp (B)
Diabetes course ≥ 3 years	-0.099	0.036	7.489	0.006	0.905	0.845-1.976
Total HOAs ≥ 0.18 μm	-0.595	0.347	2.94	0.086	0.551	0.000-0.357
Crystal type	-0.800	0.349	5.249	0.022	0.449	0.225-0.884
Complication	1.021	0.494	4.277	0.039	2.777	1.123-7.960

Note: HOAs: Higher-Order Aberrations.

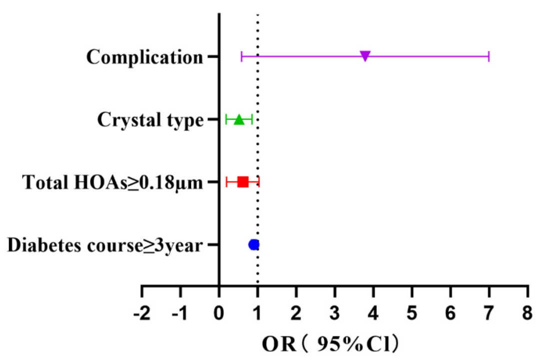

Figure 3. Forest Plot of logistic regression analysis of key factors. Note: HOAs: Higher-Order Aberrations.

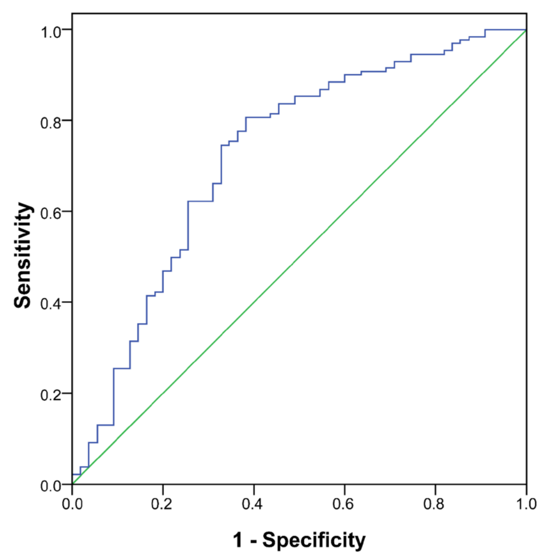

Figure 4. ROC curve analysis of multi-factor regression model.

cal risk when performed with proper intraoperative and postoperative care. Nonetheless, complications such as intraocular pressure elevation, posterior capsule opacification, and retinal detachment should be closely monitored [26].

Multivariate logistic regression identified diabetes duration ≥ 3 years, total HOAs ≥ 0.18, lens type, and postoperative complications as independent risk factors affecting visual quality scores at two years postoperatively. ROC curve analysis showed good model performance. A longer duration of diabetes was associated with worse visual outcomes, likely due to chronic microvascular changes and structural retinal damage. Total HOAs were also critical, particularly in MIOL recipients, as elevated HOAs are associated with visual distortions and reduced clarity. Interestingly, the correlation between higher HOAs and improved near vision in MIOL users suggests a dual effect - enhancing some aspects of vision while impairing others. Thus, while MIOLs may be more appropriate for patients needing multifocal functionality, clinicians must carefully consider the potential trade-offs in optical quality. Furthermore, postoperative complications were found to negatively influence long-term visual stability, reinforcing the importance of long-term follow-up.

This study has several limitations. First, its retrospective design may introduce selection bias and limit causal inference. Second, the study population was limited to a specific region, which may affect the generalizability of the findings. Third, although a two-year follow-up was conducted, the long-term progression of diabetic ocular complications warrants extended observation. Future studies should adopt a prospective, multicenter design with larger sample sizes to validate the comparative effectiveness of different IOL types in NPDR patients. The emergence of new IOL technologies, such as accommodative or extended-depth-of-focus lenses, also merits exploration in this population. In addition, integrated management strategies - combining ophthalmic treatment with systemic diabetes care - may further optimize postoperative visual outcomes and enhance patients' quality of life.

In conclusion, MIOLs significantly improve intermediate and near vision, as well as overall visual quality, in patients with NPDR. However, their association with higher-order aberrations necessitates careful patient selection and postoperative management. Personalized surgical planning that considers disease duration, visual demands, and ocular optical properties is essential for optimizing visual outcomes and enhancing quality of life in this population.

Disclosure of conflict of interest

None.

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References

[1] Perais J, Agarwal R, Evans JR, Loveman E, Colquitt JL, Owens D, Hogg RE, Lawrenson JG, Takwoingi Y and Lois N. Prognostic factors for the development and progression of proliferative diabetic retinopathy in people with diabetic retinopathy. Cochrane Database Syst Rev 2023; 2: CD013775.

[2] Sun WJ, An XD, Zhang YH, Zhao XF, Sun YT, Yang CQ, Kang XM, Jiang LL, Ji HY and Lian FM. The ideal treatment timing for diabetic retinopathy: the molecular pathological mechanisms underlying early-stage diabetic retinopathy are a matter of concern. Front Endocrinol (Lausanne) 2023; 14: 1270145.

[3] Qureshi MH and Steel DHW. Retinal detachment following cataract phacoemulsification-a review of the literature. Eye (Lond) 2020; 34: 616-631.

[4] Wang JD, Liu X, Zhang JS, Xiong Y, Li J, Li XX, Zhao J, You QS, Huang Y, Espina M, Jhanji V and Wan XH. Effects and risks of 3.2-mm transparent corneal incision phacoemulsification for cataract after radial keratotomy. J Int Med Res 2020; 48: 300060519895679.

[5] Studený P, Hamouz J and Kuchynka P. Contemporary practices in cataract surgery - subjective preferences of czech cataract surgeons. Cesk Slov Oftalmol 2022; 78: 72-78.

[6] Lapp T, Wacker K, Heinz C, Maier P, Eberwein P and Reinhard T. Cataract surgery-indications, techniques, and intraocular lens selection. Dtsch Arztebl Int 2023; 120: 377-386.

[7] Danzinger V, Schartmüller D, Lisy M, Schranz M, Schwarzenbacher L, Abela-Formanek C, Menapace R and Leydolt C. Fellow-eye comparison of monocular visual outcomes following monofocal extended depth-of-focus (EDOF) and trifocal EDOF intraocular lens implantation. Am J Ophthalmol 2024; 267: 76-83.

[8] Jukić A, Kasalica Žužul R, Pavan J, Lovrić M, Kozmar A, Plavec D, Kuzman T, Kalauz M and Jukić T. Pseudophakic cystoid macular oedema (PCME) prevention in patients with nonproliferative diabetic retinopathy (NPDR)-randomized controlled trial. Medicina (Kaunas) 2022; 58: 1667.

[9] Reste-Ferreira D, Marques IP, Santos T, Ribeiro ML, Mendes L, Santos AR, Lobo C and Cunha-Vaz J. Retinal neurodegeneration in eyes with NPDR risk phenotypes: a two-year longitudinal study. Acta Ophthalmol 2024; 102: e539-e547.

[10] Goldstein JE, Bradley C, Gross AL, Jackson M, Bressler N and Massof RW. The NEI VFQ-25C: calibrating items in the national eye institute visual function questionnaire-25 to enable comparison of outcome measures. Transl Vis Sci Technol 2022; 11: 10.

[11] Kong H, Zang S, Hu Y, Lin Z, Liu B, Zeng X, Xiao Y, Du Z, Guanrong W, Ren Y, Fang Y, Xiaohong Y and Yu H. Effect of high myopia and cataract surgery on the correlation between diabetic retinopathy and chronic kidney disease. Front Med (Lausanne) 2022; 9: 788573.

[12] Quinn N, Yang F, Ryan C, Bursell SE, Keech A, Atkinson-Briggs S, Jenkins A and Brazionis L; Centre of Research Excellence in Diabetic Retinopathy Study and TEAMSnet Study Groups. Screening for diabetic retinopathy and reduced vision among Indigenous Australians in Top End primary care health services: a TEAMSnet sub-study. Intern Med J 2021; 51: 1897-1905.

[13] Rampat R and Gatinel D. Multifocal and extended depth-of-focus intraocular lenses in 2020. Ophthalmology 2021; 128: e164-e185.

[14] Lupión Durán T, García-Ben A, Rodríguez Méndez V, Gálvez Alcázar L, García-Ben E and García-Campos JM. Study of visual acuity and contrast sensitivity in diabetic patients with and without non-proliferative diabetic retinopathy. Int Ophthalmol 2021; 41: 3587-3592.

[15] Millan MS, Clavé L, Torrents A, Armengol J and Vega F. Spatio-chromatic vision with multifocal diffractive intraocular lens. Eye Vis (Lond) 2023; 10: 32.

[16] Zhang L, Lin D, Wang Y, Chen W, Xiao W, Xiang Y, Zhu Y, Chen C, Dong X, Liu Y, Chen W and Lin H. Comparison of visual neuroadaptations after multifocal and monofocal intraocular lens implantation. Front Neurosci 2021; 15: 648863.

[17] Hall CD, Barnes CS, Gutherie AH and Lynch MG. Visual function and mobility after multifocal versus monofocal intraocular lens implantation. Clin Exp Optom 2022; 105: 70-76.

[18] Cho JY, Won YK, Park J, Nam JH, Hong JY, Min S, Kim N, Chung TY, Lee EK, Kwon SH and Lim DH. Visual outcomes and optical quality of accommodative, multifocal, extended depth-of-focus, and monofocal intraocular lenses in presbyopia-correcting cataract surgery: a systematic review and bayesian network meta-analysis. JAMA Ophthalmol 2022; 140: 1045-1053.

[19] Kanclerz P, Bazylczyk N, Przewłócka K, Khoramnia R, Atchison DA and Tuuminen R. Risk factors for corneal monochromatic aberrations and implications for multifocal and extended depth-of-focus intraocular lens implantation. J Refract Surg 2024; 40: e420-e434.

[20] Sandoval HP, Lane S, Slade SG, Donnenfeld ED, Potvin R and Solomon KD. Defocus curve and patient satisfaction with a new extended depth of focus toric intraocular lens targeted for binocular emmetropia or slight myopia in the non-dominant eye. Clin Ophthalmol 2020; 14: 1791-1798.

[21] Ozturkmen C, Kesim C, Karadeniz PG and Sahin A. Visual acuity, defocus curve and patient satisfaction of a new hybrid EDOF-multifocal diffractive intraocular lens. Eur J Ophthalmol 2022; 32: 2988-2993.

[22] Lee JS, Lin KK, Hou CH, Li PR and See LC. Chinese version of the vision-related quality of life (NEI-VFQ-25) among patients with various ocular disorders: a pilot study. Medicina (Kaunas) 2022; 58: 602.

[23] Fernández J, Burguera N, Maldonado-Carmona C, Ginel J, Sáez-Martín Á and Rodríguez-Vallejo M. Simulations of multifocal vision in patients with previous monofocal intraocular lens implantation. J Refract Surg 2023; 39: 831-839.

[24] Yuan Y, Dong M, Wen S, Yuan X and Zhou L. Retinal microcirculation: a window into systemic circulation and metabolic disease. Exp Eye Res 2024; 242: 109885.

[25] Guo D, Meng J, Zhang K, He W, Ma S, Lu ZL, Lu Y and Zhu X. Tolerance to lens tilt and decentration of two multifocal intraocular lenses: using the quick contrast sensitivity function method. Eye Vis (Lond) 2022; 9: 45.

[26] Mamalis N. Complications of multifocal intraocular lenses: what have we learned? J Cataract Refract Surg 2021; 47: 1256-1257.