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Original Research Article

Early Postoperative Visual Performance of AcrySof IQ Vivity, PanOptix, and CT Lucia Intraocular Lenses

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Name of Author:
Le Viet Cuong[1,2], Tham Truong Khanh Van[3]

Affiliation: [1]*Department of Ophthalmology, Friendship Hospital, Hanoi, Vietnam*
[2]*Hanoi Medical University, Hanoi, Vietnam*
[3] *Vietnam National Eye Hospital, Hanoi, Vietnam*

Corresponding Author:
Tham Truong Khanh Van

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Abstract: ***Objective:*** To compare early postoperative distance and near visual acuity outcomes among patients implanted with a non-diffractive extended depth-of-focus intraocular lens (AcrySof IQ Vivity), a diffractive multifocal intraocular lens (AcrySof IQ PanOptix), and a monofocal intraocular lens (ZEISS CT Lucia 621PY). ***Methods:*** This controlled interventional clinical study was conducted at Friendship Hospital, Vietnam, from March to December 2024. A total of 150 patients undergoing phacoemulsification cataract surgery were consecutively enrolled and allocated into three equal groups according to the implanted IOL type (n = 50 per group). Postoperative assessments were performed at 1 month and 3 months. Distance visual acuity was measured under uncorrected and corrected conditions at multiple viewing distances, and near visual acuity at 40 cm was evaluated using the Jaeger scale and analyzed in grouped categories. Group comparisons were performed using the chi-square test and Kruskal–Wallis test. ***Results:*** At 1 month postoperatively, uncorrected distance visual acuity did not differ significantly among groups at 1.5 m but showed significant differences at shorter distances. Corrected distance visual acuity differed significantly among groups at most tested distances except 2.0 m. Near visual acuity at 40 cm differed significantly among the three IOL groups at both 1 month and 3 months, with the multifocal IOL providing the best near performance, the monofocal IOL the least, and the EDOF IOL demonstrating intermediate results. ***Conclusion:*** Non-diffractive EDOF, multifocal, and monofocal IOLs exhibit distinct early postoperative visual performance profiles. While distance vision was generally comparable at longer distances, significant differences were observed at intermediate and near ranges.

Keywords: Cataract surgery; extended depth-of-focus intraocular lens; multifocal intraocular lens; monofocal intraocular lens; visual acuity; Vivity; PanOptix.

INTRODUCTION

Cataract is one of the leading global causes of visual impairment and blindness, and cataract surgery represents one of the most frequently performed surgical procedures worldwide [1-3]. In the United States alone, cataracts currently affect approximately 17% of the population, with projections estimating that more than 140 million individuals will be affected by 2050 [2]. As life expectancy increases and older adults remain professionally and socially active, the goals of cataract surgery have shifted beyond visual rehabilitation toward refractive optimization. Contemporary patients increasingly expect good unaided vision at distance, intermediate, and near ranges, as well as a high degree of spectacle independence following surgery [1, 4-6]. This trend is further reinforced by the growing global burden of presbyopia, which is expected to peak at approximately 2.1 billion affected individuals by 2030, intensifying demand for presbyopia-correcting intraocular lenses (IOLs) and spectacle-free visual function [5].

Monofocal IOLs remain the most commonly implanted lenses worldwide and provide excellent distance visual acuity; however, their limited depth of focus necessitates spectacle use for intermediate and near visual tasks such as computer work, smartphone use, and reading [1, 4, 6]. Multifocal and trifocal IOLs were developed to address this limitation and have demonstrated improved near and intermediate vision and increased spectacle independence compared with monofocal lenses [4, 7, 8]. However, these benefits are frequently accompanied by trade-offs, including reduced contrast sensitivity, a higher incidence of photic phenomena such as halos and glare, and greater sensitivity to residual refractive error and ocular comorbidities [1, 5, 9]. As a result, not all patients are suitable candidates for diffractive multifocal IOLs. Extended depth-of-focus (EDOF) IOLs have emerged as an alternative approach, designed to create an elongated focal zone that provides a continuous range of vision from distance through intermediate, with functional near vision, while maintaining non-inferior distance acuity compared with monofocal IOLs [1, 5, 10]. Non-diffractive EDOF designs, such as the AcrySof IQ Vivity IOL, use wavefront-shaping optics to extend depth of focus without light splitting, thereby aiming to preserve contrast sensitivity and minimize photic phenomena [10, 11]. Previous studies have shown that Vivity provides superior intermediate visual acuity compared with monofocal IOLs, near visual acuity intermediate between monofocal and multifocal designs, and substantially lower rates of halos and glare than classic multifocal IOLs [4, 11]. Despite increasing international evidence supporting the clinical performance of non-diffractive EDOF IOLs, comparative data evaluating EDOF, multifocal, and monofocal IOLs within the same clinical setting remain limited, particularly in Southeast Asia. In Vietnam, where cataract surgery volume is high and patient expectations regarding postoperative visual performance and spectacle independence are rapidly evolving, real-world evidence comparing functional visual outcomes across different IOL technologies is scarce. Moreover, data assessing distance and near visual acuity at multiple viewing distances in Vietnamese patients are lacking. Therefore, the present study aimed to compare postoperative visual outcomes among patients implanted with a non-diffractive EDOF IOL (AcrySof IQ Vivity), a diffractive multifocal IOL (AcrySof IQ PanOptix), and a monofocal IOL (ZEISS CT Lucia 621PY), with a focus on distance and near visual acuity at 1 and 3 months following cataract surgery.

MATERIALS AND METHOD

Study Design and Setting

This study was conducted as a controlled interventional clinical study at Friendship Hospital, Vietnam, from March 2024 to December 2024. Patients diagnosed with senile or presenile cataract and indicated for phacoemulsification cataract surgery were consecutively recruited and allocated into three study groups according to their visual needs and financial conditions. All participants underwent standard phacoemulsification cataract surgery performed by experienced surgeons using a uniform surgical technique and postoperative care protocol. The three study groups consisted of implantation of a non-diffractive extended depth-of-focus intraocular lens (AcrySof IQ Vivity®), a diffractive multifocal intraocular lens (AcrySof IQ PanOptix®), or a monofocal intraocular lens (ZEISS CT LUCIA 621PY).

Clinical Examination and Follow-up

All patients underwent a comprehensive ophthalmologic examination before surgery and were followed up at 1 month and 3 months postoperatively. Preoperative assessment included measurement of best-corrected distance visual acuity, intraocular pressure, axial length, slit-lamp biomicroscopy, and fundus examination. Postoperative evaluations focused on visual performance and included assessment of uncorrected and corrected distance visual acuity at multiple distances, as well as near visual acuity at 40 cm. Distance visual acuity was assessed under standardized photopic lighting conditions at defined viewing distances, and near visual acuity was measured using the Jaeger scale. For analytical purposes, near visual acuity outcomes were categorized into grouped Jaeger levels (J1, J2, and ≥J3). All examinations were conducted following a standardized protocol to ensure consistency across study groups and follow-up visits.

Outcome Measures

The primary outcome measures were postoperative visual performance and visual function across different viewing distances. Distance visual acuity was assessed at 1 month postoperatively under uncorrected and corrected conditions at multiple distances, including 1.5 m, 1.0 m, 0.5 m, and 0.0 m for uncorrected visual acuity, and 0.5 m, 1.0 m, 1.5 m, 2.0 m, and 2.5 m for corrected visual acuity. Visual acuity values were recorded in logMAR units and summarized as mean ± standard deviation.

Near visual acuity was evaluated at a working distance of 40 cm using the Jaeger scale at 1 month and 3 months after surgery. For analytical purposes, Jaeger scores were grouped into three categories: J1, J2, and ≥J3. The distribution of near visual acuity categories was compared among the three intraocular lens groups at each postoperative time point.

Baseline demographic and preoperative clinical characteristics, including age, sex, operated eye, preoperative intraocular pressure, axial length, and implanted intraocular lens power, were also analyzed to assess comparability among groups.

Statistical Analysis

All data were analyzed using SPSS software version 23.0 (IBM Corp., Armonk, NY, USA). Categorical

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variables were summarized as frequencies and percentages, while continuous variables were expressed as means with standard deviations. Comparisons of categorical variables among the three intraocular lens groups were performed using the chi-square test.

Because several continuous variables did not meet the assumption of normal distribution, comparisons among groups for continuous outcomes, including age, preoperative intraocular pressure, axial length, intraocular lens power, and postoperative visual acuity measures, were conducted using the Kruskal–Wallis test. A two-sided *p* value of less than 0.05 was considered statistically significant for all analyses.

Ethical Considerations

The study protocol was reviewed and approved by the institutional ethics committee of HMUIRB (approval code: 1298). Written informed consent was obtained from all participants prior to enrollment. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki.

RESULTS

Table 1 summarizes the baseline demographic and preoperative characteristics of the 150 study participants across the three intraocular lens groups. The proportion of male patients differed significantly among groups, accounting for 76.0% in the Vivity group and 54.0% in both the Lucia and PanOptix groups (p = 0.033). The distribution of the operated eye was comparable between groups, with no significant difference observed (p = 0.707). Mean age differed significantly among groups, with lower mean age in the Vivity group compared with the Lucia and PanOptix groups (p = 0.006). Preoperative intraocular pressure also showed a statistically significant difference across groups (p = 0.039). No significant difference was observed in axial length (p = 0.223), whereas mean implanted IOL power differed significantly among the three groups (p = 0.015).

Table 1. Baseline demographic and preoperative characteristics of the study participants (n = 150)

Characteristics	Category	Vivity (n = 50)	Lucia (n = 50)	PanOptix (n = 50)	*p* value
Gender, n (%)	Male	38 (76.0)	27 (54.0)	27 (54.0)	0.033[1]
Operated eye, n (%)	Right eye	27 (54.0)	26 (52.0)	23 (46.0)	0.707[1]
Age (years)	Mean ± SD	66.6 ± 9.45	71.38 ± 6.25	71.14 ± 7.11	0.006[2]
Preoperative intraocular pressure (mmHg)	Mean ± SD	17.32 ± 1.70	17.04 ± 0.83	17.50 ± 0.61	0.039[2]
Axial length (mm)	Mean ± SD	23.57 ± 0.86	23.44 ± 1.01	23.20 ± 1.57	0.223[2]
IOL power (D)	Mean ± SD	20.03 ± 1.65	20.84 ± 1.89	19.59 ± 2.37	0.015[2]

[1] Chi-square test; [2] Kruskal–Wallis test.

Table 2 presents distance visual acuity outcomes at 1 month postoperatively for uncorrected and corrected conditions across multiple viewing distances. For uncorrected distance visual acuity, no significant difference was observed at 1.5 m (p = 0.600), while statistically significant differences were found at 1.0 m (p = 0.021), 0.5 m (p = 0.001), and 0.0 m (p < 0.001). For corrected distance visual acuity, significant differences among the three groups were observed at 0.5 m (p < 0.001), 1.0 m (p < 0.001), and 1.5 m (p = 0.009). No statistically significant difference was noted at 2.0 m (p = 0.093), whereas a significant difference was present at 2.5 m (p = 0.036).

Table 2. Distance visual acuity at 1 month postoperatively (logMAR)

Visual acuity (distance)	Vivity (n = 50)	Lucia (n = 50)	PanOptix (n = 50)	*p* value†
Uncorrected distance visual acuity				
1.5 m	4.42 ± 1.92	4.24 ± 1.86	4.64 ± 1.94	0.600
1.0 m	2.88 ± 1.81	2.72 ± 1.60	3.30 ± 1.36	0.021
0.5 m	1.32 ± 1.06	1.30 ± 0.99	2.00 ± 1.12	0.001
0.0 m	0.54 ± 0.65	0.28 ± 0.54	0.76 ± 0.62	<0.001
Corrected distance visual acuity				
0.5 m	0.94 ± 0.71	0.72 ± 0.73	1.42 ± 0.93	<0.001
1.0 m	1.44 ± 0.88	1.64 ± 0.88	2.34 ± 1.08	<0.001
1.5 m	2.32 ± 1.11	2.82 ± 1.29	3.16 ± 1.46	0.009
2.0 m	3.34 ± 1.49	4.00 ± 1.50	3.76 ± 1.95	0.093
2.5 m	4.78 ± 1.72	5.62 ± 2.05	4.84 ± 2.48	0.036

† Kruskal–Wallis test.

Table 3 describes near visual acuity at 40 cm using the grouped Jaeger scale at 1 month and 3 months postoperatively. At 1 month, the distribution of near visual acuity categories (J1, J2, and ≥J3) differed significantly among the three groups (p < 0.001). At 3 months, a similar pattern was observed, with significant differences in the distribution of grouped near visual acuity levels across the groups (p < 0.001). At both time points, the proportions of patients in

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each Jaeger category varied among the Vivity, Lucia, and PanOptix groups.

Table 3. Near visual acuity at 40 cm at 1 and 3 months postoperatively

Near visual acuity at 40 cm	Vivity (n = 50)	Lucia (n = 50)	PanOptix (n = 50)	*p* value†
1 month				
J1	7 (14.0)	1 (2.0)	2 (4.0)	<0.001
J2	19 (38.0)	14 (28.0)	36 (72.0)	
≥ J3	24 (48.0)	35 (70.0)	12 (24.0)	
3 months				
J1	3 (6.0)	1 (2.0)	6 (12.0)	<0.001
J2	19 (38.0)	11 (22.0)	31 (62.0)	
≥ J3	28 (56.0)	38 (76.0)	13 (26.0)	

† **Chi-square test.**

DISCUSSION

This study provides a comparative evaluation of early postoperative visual outcomes among patients implanted with a non-diffractive extended depth-of-focus (EDOF) IOL (AcrySof IQ Vivity), a diffractive multifocal IOL (AcrySof IQ PanOptix), and a monofocal IOL (ZEISS CT Lucia). Baseline differences in age, sex distribution, preoperative intraocular pressure, and implanted IOL power reflect real-world patient selection rather than randomized allocation, a pattern commonly reported in clinical practice. Importantly, axial length and operated eye distribution were comparable among groups, minimizing the potential influence of biometric confounders on postoperative visual acuity outcomes.

At 1 month postoperatively, distance visual acuity outcomes demonstrated that uncorrected visual acuity at longer viewing distances was broadly comparable among the three IOL groups, with no significant difference at 1.5 m. This finding aligns with previous reports indicating that modern monofocal, multifocal, and EDOF IOLs all provide excellent distance visual acuity early after surgery [12]. However, significant intergroup differences emerged at shorter distances, particularly at 1.0 m, 0.5 m, and 0.0 m, suggesting that optical design increasingly influences visual performance as viewing distance shifts toward intermediate and functional near ranges. These results are consistent with the concept that EDOF and multifocal IOLs extend usable vision beyond distance, whereas monofocal lenses remain limited in this regard [4, 5].

Corrected distance visual acuity further highlighted differences across IOL types, particularly between 0.5 m and 1.5 m. Even under corrected conditions, statistically significant differences were observed, underscoring that optical design characteristics affect functional vision beyond refractive accuracy alone. The lack of a significant difference at 2.0 m suggests convergence of distance performance across lenses at this range, whereas differences reappeared at 2.5 m. These findings are consistent with prior multicenter studies reporting similar corrected distance acuity among IOL types but divergent intermediate performance, particularly favoring EDOF designs [4, 12].

Near visual acuity outcomes at 40 cm showed clear and persistent differences among groups at both 1 month and 3 months. The PanOptix group achieved higher proportions of patients in the better near-vision categories (J1 and J2), whereas the monofocal Lucia group had a larger proportion of patients classified as ≥J3, indicating reduced near performance. The Vivity group consistently demonstrated intermediate performance between the multifocal and monofocal lenses. This pattern closely mirrors international data on Vivity, which report near visual acuity that is inferior to multifocal IOLs but clearly superior to monofocal lenses, providing functional near vision sufficient for many daily tasks [4, 11, 13].

The stability of near visual acuity distributions between 1 month and 3 months suggests that early postoperative outcomes largely reflect inherent optical properties rather than transient adaptation effects. This observation is supported by prospective studies of Vivity showing stable refractive outcomes and consistent binocular distance and intermediate visual acuity by 3 months, with defocus curves maintaining ≤0.1 logMAR over a wide dioptric range [11]. Similarly, toric Vivity studies have demonstrated minimal lens rotation and stable astigmatic correction as early as 1 month postoperatively, indicating that early functional outcomes are reliable predictors of medium-term performance [14].

The findings of this study have direct implications for clinical decision-making in cataract surgery. Multifocal IOLs remain the most effective option for maximizing near visual acuity and spectacle independence but may not be suitable for all patients due to optical trade-offs. Monofocal IOLs continue to provide excellent distance vision but offer limited functional near and intermediate performance. Non-diffractive EDOF IOLs such as Vivity represent a balanced alternative, delivering strong distance and intermediate vision with functional near acuity and a lower risk of photic phenomena, as reported in international studies [4, 11]. This profile may be particularly advantageous for patients with

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intermediate-heavy visual demands, mild ocular comorbidities, or concerns about halos and glare.

This study has several limitations. The non-randomized design may have introduced selection bias, as reflected by baseline differences in age and sex distribution. The follow-up period was limited to 3 months, preventing assessment of long-term visual stability, neural adaptation, and patient-reported satisfaction. Additionally, contrast sensitivity, defocus curve analysis, and detailed dysphotopsia assessments were not included, limiting direct comparison with international EDOF studies that emphasize these outcomes. Finally, the single-center setting may restrict generalizability to other populations.

CONCLUSION

In conclusion, this study demonstrates significant differences in early postoperative distance and near visual acuity among patients implanted with non-diffractive EDOF, multifocal, and monofocal intraocular lenses. While distance visual acuity was broadly comparable at longer viewing distances, meaningful differences emerged at intermediate and near ranges, reflecting the optical design characteristics of each IOL type. Non-diffractive EDOF lenses provided intermediate performance between monofocal and multifocal designs, offering a balanced visual profile across distances. These findings support the role of EDOF IOLs as a viable alternative for patients seeking enhanced functional vision with fewer trade-offs, and they contribute valuable real-world evidence to guide IOL selection in clinical practice.

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