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Research Article

Impact of Interprocedural Intraocular Lens Selection Changes on Refractive Outcomes in Delayed Sequential Bilateral Cataract Surgery: A Retrospective Study of a Single Surgeon's Practice Precipitating Conversion to Immediately Sequential Bilateral Cataract Surgery in Northern Ontario, Canada

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Abstract

Objective: To evaluate whether changing the calculated intraocular lens (IOL) power for the second eye, based on the refractive outcome of the first eye, in delayed sequential bilateral cataract surgery (DSBCS), enhanced refractive results in a single surgeon's practice.

Design: Retrospective comparative-effectiveness study.

Participants: Patients undergoing DSBCS with monofocal IOLs, whose first-eye IOL was targeted for close to plano based on optical biometry, at a regional ophthalmology center in Northern Ontario. Exclusion criteria included cases with any other IOLs or power determination by intraoperative aberrometry.

Methods: Cases performed between January 2022, and December 2023 were reviewed. Statistical analyses were performed using Microsoft Excel and SciPy.

Main Outcome Measures: Age, sex, interval between surgeries, and refractive outcomes for each eye were evaluated. Success of second-eye IOL adjustment was determined by comparing the predicted spherical equivalent error (SEE) in the second eye with the predicted outcome based on biometry-suggested IOL.

Results: 116 of 688 DSBCS cases were included after exclusions. No significant difference in SEE ($p = 0.13$) was observed between 35 cases with second-eye IOL modifications (mean SEE ± standard deviation = 0.57 ± 0.47 diopters) and 81 unmodified IOL cases (0.43 ± 0.38 diopters). Among the IOL-modified cases, the mean difference between chosen lens and biometry-suggested lens SEEs was 0.0343D ($p = 0.61$; 95% CI: -0.0994D to +0.1680D), confirming equivalence between groups.

Conclusions: Interprocedural IOL adjustments in DSBCS in this single surgeon's practice did not enhance refractive outcomes. These results align with broader studies suggesting no refractive advantage for DSBCS over ISBCS.

Keywords: Immediately Sequential Bilateral Cataract Surgery; Delayed Sequential Bilateral Cataract Surgery; Intraocular Lens; Refractive Outcomes; Refractive Surprise; Intraocular Lens Power; Quality Improvement

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Abbreviations

ISBCS: Immediately Sequential Bilateral Cataract Surgery; DSBCS: Delayed Sequential Bilateral Cataract Surgery; IOL: Intraocular Lens; REB: Research Ethics Boards; SEE: Spherical Equivalent Error.

Introduction

Immediately sequential bilateral cataract surgery (ISBCS) offers multiple advantages about which much has been written. It requires only one operating room visit and half the postoperative visits, making the surgical journey more manageable for patients and their families. Patients, their families, the surgical centre, and the surgeon all express preference for ISBC as it greatly simplifies the entire surgical process, saves time and money for the patient and family and is more efficient for the surgical centre and the surgeon, with an overall reduction in cost over DSBCS of about 30%. Yet, many ophthalmologists prefer delayed sequential bilateral cataract surgery (DSBCS) [1,2]. In Canada, just over a third of ophthalmologists do not perform ISBCS, while a second third do so only occasionally. Approximately half state they want to assess the first eye's refractive outcome before operating on the second, as DSBCS provides a potential opportunity to alter intraocular lens (IOL) selection for the second eye, previously calculated by preoperative optical biometry [1]. Many have stated that even though large studies have not shown that the interprocedural option to change IOL power for the second eye has been beneficial, they remain convinced that this may help in unusual refractive surprises in their own practices, where averaging of large numbers would not occur. We designed this paper to address this concern.

In Northeastern Ontario, Canada, a significant and ongoing backlog for cataract surgery has prompted the only full-time ophthalmologist in the region, who specializes in retinal issues and has favoured DSBCS, to explore ISBCS, and therefore the extent to which second-eye IOL adjustments impacted refractive outcomes in his practice. Like many others, he believed that in his cases with suboptimal refractive results in the first eye, altering the calculated IOL for the second eye potentially enhanced the refractive outcome. Thus, for this study, we hypothesized:

- If IOLs were modified only for cases with unsatisfactory first-eye outcomes, modified and unmodified IOL second eyes should have similar refractive outcomes.
- The refractive outcomes in second eyes with modified IOLs would be closer to the surgeon's target (the predicted spherical equivalent of the Lenstar-suggested IOL) than if the original Lenstar-suggested IOL was used.

Materials and Methods

This retrospective comparative-effectiveness study is classified as a quality improvement project by the Government of Canada Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans – TCPS 2 (2022) Article 2.5 and does not fall under the scope of institutional research ethics boards (REB). Institutional REB approval was not applicable and, therefore, not requested or received for this study.

A non-clinician investigator reviewed charts, including DSBCS patients who had at least one of two cataract extractions and spherical IOL placements between January 1, 2022, and December 31, 2023. The review included preoperative optical biometry, as well as interprocedural and postoperative refractive assessments conducted by a certified ophthalmic technician. Preoperative optical biometry (Lenstar LS 900, Haag-Streit; Mason, OH, USA) was performed in the outpatient clinic for all patients. The Holladay II and Barrett formulas were used for IOL power calculations to choose the IOL power that would produce a predicted refractive outcome closest to plano. Postoperative subjective refraction was manually assessed approximately four weeks after surgery. Exclusion criteria included patients whose IOLs were selected based on intraoperative aberrometry (measured by author A.O. using ORA - Optiwave Refractive Analysis, Alcon Laboratories, Fort Worth, Texas), as well as patients with non-monofocal IOLs (such as multifocal or TORIC IOLs) or atypical IOL placements.

Outcome measures included age, sex, time in days between cases, the absolute spherical equivalent error (SEE, which is the difference between the predicted and postoperative spherical equivalent) for each eye, and the SEE that would have occurred with the biometry-suggested IOL (calculated using -0.66D spectacle plane refractive power change per +1D IOL power change). Descriptive statistics (i.e., counts, percentages, means, and standard deviations) were used to summarize outcome measures. Inferential statistics (paired two-sample t-test for means, chi-square test for independence, two-sample t-test assuming unequal variances, and confidence intervals) were used to compare the SEEs and assess the statistical

significance and power of any differences between groups. These calculations were performed using Microsoft Excel, the Python statistical packages SciPy version 1.14.1.

Results and Discussion

Results

Disqualifications from the study included 572 patients for the reasons mentioned above and missed postoperative assessments due to travel (Table 1). Out of 116 patients meeting the inclusion criteria, 35 had their second eye's IOL changed from the suggested IOL power derived from preoperative optical biometry and 81 received power-unmodified second-eye IOLs.

Disqualification Reason	n
Data absent or assessments missed due to travel	185
Target for first eye not plano	157
Use of ORA in either eye	64
Toric IOL implanted in either eye	60
Surgery performed on only one eye	103
Other (e.g., multifocal lens, sulcus IOL placement)	3
Total Exclusions	572

Table 1: Patients Excluded from Study.

First-eye cases all received the biometry-suggested IOL. Subsequently, the second-eye IOL-modified group consisted of those with a first eye mean absolute SEE significantly greater (mean: 0.62 D, 95% CI: 0.49 to 0.76 D) than the IOL-unmodified group (mean: 0.35 D, 95% CI: 0.27 to 0.43 D; p = 0.001). There was no significant difference in age, sex distribution, or interval between cases when comparing the unmodified and modified groups.

Refractive results for the second-eye cases are summarized in Table 2.

With respect to hypothesis 1: If IOLs were modified only for cases with unsatisfactory first-eye outcomes, modified and unmodified IOL second eyes should have similar refractive outcomes: The mean second-eye absolute SEEs of IOL-unmodified (mean: 0.43 D, 95% CI: 0.34 to 0.51 D) and IOL-modified (mean: 0.57 D, 95% CI: 0.41 to 0.72 D) were not significantly different (p = 0.13), although they were marginally better in the unmodified group. The mean inter-group difference was only 0.14 D and its 95% confidence interval (−0.04 to +0.32 D) is less than the smallest possible IOL change (±0.5 D). This suggests that the IOL-modified group's second-eye outcomes were comparable to the IOL-unmodified group, which would seem to support the idea that interprocedural adjustment of IOL powers after a significant ametropic result in the first eye may be beneficial.

Attribute	Eye 2 IOL Unmodified	Eye 2 IOL Modified		p value
n	81	35		
Age (years)	75 ± 7.4	73 ± 8.0		0.23 (ns)
Sex (n, female)	49	19		0.53 (ns)
Time between surgeries (days, M ± SD)	406 ± 753	463 ± 704		0.70 (ns)
First Eye SEE (diopters, M ± SD)	0.35 ± 0.36	0.62 ± 0.41		0.001 (s)
Second Eye SEE (diopters, M ± SD)	0.43 ± 0.38	0.57 ± 0.47		0.13 (ns)
		IOL Modified Result	Predicted Result if Unmodified	
Second Eye SEE (diopters, M ± SD)		0.57 ± 0.47	0.60 ± 0.47	0.61 (ns)

Table 2: Study Results.

SEE, spherical equivalent error; SD, standard deviation; s, significant; ns, not significant.

With respect to hypothesis 2: The refractive outcomes in second eyes with modified IOLs would be closer to the surgeon's target (the predicted spherical equivalent of the Lenstar-suggested IOL) than if the original Lenstar-suggested IOL was used: The SEEs in IOL-modified cases were compared to what they would have been if the recommended lens had not been modified (predicted SEE). The mean difference between post-op SEE and the predicted SEE with the original lens was −0.034 D (95% CI: +0.099 to −0.168 D; p = 0.61). This difference is essentially zero and the very narrow confidence interval (compared to ±0.5 D) suggests that the chosen adjustment had a negligible impact.

These findings together support that both approaches produce the same amount of refractive error on average. These results suggest that something was unusual about the first eyes that yielded an ametropic surgical result, and that the first eye result is not necessarily transferable to the second eye's biometry, as the patient's two eyes may be different.

Discussion

This study evaluated the effectiveness of manually adjusting the IOL in DSBCS second-eye cases, when the first eye's SEE was unsatisfactory. It was found that second-eye outcomes in the IOL-modified and unmodified groups were similar, with the modified group having a slightly higher mean SEE (+0.14 D, 95% CI −0.04 to +0.32), a difference that is clinically not meaningful. Furthermore, within the modified group, the difference between the actual and predicted SEE, had the original biometry-suggested IOL been used, was close to zero (−0.034 D, 95% CI −0.168 to +0.099), indicating that no measurable benefit had resulted from the IOL adjustments.

Although our study is limited by incomplete documentation inherent to retrospective chart review data, which caused us to exclude 27% of cases conducted during the study period due to missed appointments of patients living far from the surgical centre, these findings align with more comprehensive studies [3-5]. In a multicentre, non-inferiority randomized clinical trial (n = 865), Spekreijse., *et al*. [6] compared ISBCS with DSBCS, allowing surgeons to adjust IOL lens power based on postoperative refractive outcomes of the first eye. The implanted IOL power of the DSBCS second eye differed from the planned power in only 4% of the 425 DSBCS eyes, and their refractive results did not differ significantly from those of the unchanged IOL second eyes, similar to our findings [6]. They also demonstrated non-inferiority for ISBCS compared with DSBCS by showing that the proportion of second eyes within a target refraction of 0.5 D was 79% in ISBCS and 77% in DSBCS, an insignificant difference (p = 0.470) [6]. The conclusions of a recent Cochrane review also suggest that DSBCS does not offer refractive error benefits over ISBCS, challenging the commonly proposed potential advantage of possible interprocedural IOL selection change [5]. Our findings further support this hypothesis. Additionally, the development of newer IOL calculation tools such as the Kane formula and AI-driven calculators like the Hill RBF continues to reduce the risk of refractive surprises in cataract surgery [7,8].

Our Northern Ontario surgeon then sought other reasons to avoid ISBCS. Another common concern about ISBCS is the risk of complications. In a recent survey, 57% of Canadian ophthalmologists also expressed worries about the possibility of bilateral complications associated with ISBCS [1]. However, published research shows that ISBCS has a safety and efficacy profile comparable to DSBCS [3,9]. A large recent retrospective study found no specific complications related to ISBCS [10]. In the RCT by Spekreijse., *et al*. [6], the authors reported no cases of endophthalmitis in either group, and adverse events were similar. The risk of infection in ISBCS is as low as that in unilateral surgeries [11].

ISBCS is increasingly performed more regularly in Canada. While ISBCS is more common among early-career ophthalmologists at academic centres, especially in Quebec [1], and there has been a tenfold increase in Ontario since 2016 [12]. Adoption of ISBCS may be linked to growing evidence of comparable treatment outcomes and surgeons' desire to boost efficiency—freeing up operating room slots and cutting down perioperative appointments. ISBCS can help reduce regional backlogs by enabling surgeons to treat more patients, lowering total appointments from five to three. In Ontario, ISBCS has been shown to be significantly less costly than DSBCS [12] and saved the healthcare system around $19 million in 2022 [13]. Increasing evidence of similar refractive results and safety, along with better efficiency and cost savings, all support expanding the use of ISBCS. Canada merely serves as an example of the benefits of ISBCS in a system where the safety protocols of the International Society of Bilateral Cataract Surgeons have been scrupulously followed [14].

Conclusion

As a result of this study, the northeastern Ontario surgeon (author A.O.), whose cases were examined in this report, decided to henceforth routinely offer ISBCS to interested patients for whom no contraindications exist.

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Conflict of Interest

None.

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