The Scientific Temper (2025) Vol. 16 (7): 4579-4585
Doi: 10.58414/SCIENTIFICTEMPER.2025.16.7.09
E-ISSN: 2231-6396, ISSN: 0976-8653
https://scientifictemper.com/

RESEARCH ARTICLE

Short-term changes in lens vault post implantable collamer lens surgery in myopic patients

Mantsha Rayeen[1*], Roshni Sengupta[2], Sanjay Chaudhary[3]

Abstract

Purpose: To evaluate short-term postoperative changes in lens vault and associated ocular parameters following Implantable Collamer Lens (ICL) implantation in myopic patients, and to identify preoperative predictors of vault behavior during the initial 15 days after surgery.

Subject and Methods: This cohort study included 202 eyes from 101 patients with myopia and astigmatism who underwent bilateral ICL implantation at Chaudhary Eye Centre & Laser Vision between October 2023 and December 2024. Preoperative and postoperative assessments included best-corrected visual acuity (BCVA), intraocular pressure (IOP), anterior chamber depth (ACD), and central vault measurements using the Anterion AS-OCT. Follow-ups were conducted on postoperative day 1 (POD 1) and day 15 (POD 15). Statistical analysis involved Wilcoxon tests, Fisher's exact test, and mixed-model logistic regression to identify factors influencing vault changes.

Results: A significant reduction in lens vault was observed between POD 1 and 15 (mean difference = 50.5 µm; $p < 0.001$). ACD increased (mean = 0.0399 mm; $p < 0.001$), while IOP decreased (mean = 1.5 mmHg; $p < 0.001$). BCVA showed modest improvement ($p = 0.041$). Vault decreased in 75.2% of eyes, remained unchanged in 2%, and increased in 22.8%. Multivariate analysis revealed spherical equivalent (SE) as the only significant predictor of vault reduction ($p < 0.001$), with higher myopia associated with greater vault decrease.

Conclusion: Early postoperative changes in vault are significantly influenced by the degree of myopic correction. Higher preoperative myopia is associated with greater vault reduction, underscoring the importance of individualized preoperative planning and early postoperative monitoring to ensure optimal outcomes following ICL implantation.

Keywords: Implantable Collamer Lens, Intraocular Pressure, Spherical Equivalent, Anterior Chamber Depth, Best Corrective Visual Acuity, Vault Change.

Introduction

Implantable Collamer Lenses (ICLs) are frequently preferred as the primary surgical option for correcting high myopia (Uusitalo RJ et al., 2002; Wang X et al., 2016). One of the major postoperative considerations is achieving an optimal vault following ICL implantation (Igarashi A, Shimizu K, Kamiya K, 2014). Research indicates that vault height is influenced by various factors over time, including optical parameters like accommodation and pupil diameter (Koch DD et al., 1996; Neri A et al., 2015; Lee H et al., 2014; Lindland A et al., 2010).

The vault refers to the space between the back surface of the ICL and the front surface of the crystalline lens and serves as a crucial indicator of the procedure's safety. A vault ranging from 250 to 750 µm is generally considered to be within the safe range (Fernandes P et al., 2011; Serra P et al., 2021). If the vault is too low, it may result in direct contact with the crystalline lens or disrupt aqueous humor flow, potentially leading to anterior capsular opacification or cataract formation. Conversely, an excessively high vault may result in contact with the iris, leading to complications such as inflammation, elevated intraocular pressure, angle-closure glaucoma, or pigment dispersion. Typically, the vault decreases progressively after surgery and exhibits dynamic changes in response to accommodation (Lee H et al., 2014). It is a variable parameter that can shift over time (Marchini G et al., 2004; Alfonso JF et al., 2012) and fluctuate depending on accommodation status (Petternel V et al., 2004).

[1]M. Optometry student, Department of Optometry, School of Healthcare and Allied Sciences, G D Goenka University, Gurugram, Haryana, India.

[2]Assistant Professor, Department of Optometry, School of Healthcare and Allied Sciences, G D Goenka University, Gurugram, Haryana, India.

[3]MS Cataract and Refractive Consultant, Medical Director, Chaudhary Eye Centre & Laser Vision, New Delhi, India.

***Corresponding Author:** Mantsha Rayeen, M. Optometry student, Department of Optometry, School of Healthcare and Allied Sciences, G D Goenka University, Gurugram, Haryana, India, E-Mail: mantshakhan015@gmail.com

How to cite this article: Rayeen, M., Sengupta R., Chaudhary, S. (2025). Short-term changes in lens vault post implantable collamer lens surgery in myopic patients. The Scientific Temper, **16**(7):4579-4585.

Doi: 10.58414/SCIENTIFICTEMPER.2025.16.7.09

Source of support: Nil

Conflict of interest: None.

© *The Scientific Temper. 2025*

Received: 21/06/2025 **Accepted:** 08/07/2025 **Published**: 31/07/2025

It offers a permanent yet reversible correction with minimal risk and quick recovery. The Anterion (Heidelberg Engineering), an advanced swept-source AS-OCT technology, allows detailed visualization of the anterior chamber and crystalline lens, enabling a thorough examination of factors affecting the ICL vault. Therefore, this study aims to evaluate short-term postoperative changes in ICL vault and other relevant parameters anterior chamber depth (ACD), intra-ocular pressure (IOP), and best corrected visual acuity (BCVA) over time in myopic patients. It also seeks to analyze the changes observed across different ICL vault categories following ICL surgery and to identify preoperative factors that may influence lens vault changes. These evaluations will provide insights into the factors affecting vault stability and visual outcomes in patients undergoing ICL implantation.

Subject and Methods

Study Design and Ethical Considerations

This cohort study was conducted involving 202 eyes (101 Patients) at the Department of Ophthalmology Chaudhary Eye Centre & laser Vision from October 2023 and December 2024. Ethical approval was obtained from the Institutional Ethics Committee of Chaudhary Eye Centre & Laser Vision (No. EC009/0308/2024) prior to the commencement of the study. All procedure adhered to the tenets of the declaration of Helsinki, and patient confidentiality was strictly maintained throughout the study. Informed Consent was obtained from all participants after explaining the purpose, procedure, and potential outcomes of the study.

Participants Selection

This study outlines the procedures for patient selection, preoperative assessments, ICL lens calculation, and postoperative evaluations. The study included phakic patients aged 18 to 35 years with myopia ranging from -1.00Dsph to -20.00Dsph and astigmatism from -0.50Dcyl to -6.00Dcyl. Only patients who underwent ICL surgery in both eyes were considered. Patients with conditions such as strabismus, nystagmus, or extraocular muscle restrictions were excluded, as well as individuals with ocular diseases, a history of ocular surgery, or hyperopia. Additionally, patients who missed follow-up appointments were excluded to preserve the study's accuracy and integrity.

Pre-operative Procedure

Data collected for analysis included patient demographics. All patients underwent comprehensive ophthalmic examinations, including best-corrected distance visual acuity evaluation (using a Snellen chart), slit-lamp biomicroscopy (Zeiss), tonometry (non-contact tonometer; CT-80, Topcon corporation, Japan), and fundus examination using a 90D lens. The refractive diopter was measured using a retinoscope (Heine, Germany) and converted into the spherical equivalent (SE). The Anterion (Heidelberg Engineering GmbH Max-Jarecki-Str.8 69115 Heidelberg, Germany) device was used to measure the ICL lens parameters and also obtain the anterior chamber depth (ACD). The data obtained from these tests guided the ICL lens calculation. Retinoscopy and Anterion examinations were performed in a darkroom, while all other examinations were conducted under standard room lighting conditions.

Post-operative Procedure

Post-operative assessments were conducted at two key follow-up points: the Post-operative day (POD) 1 and 15. On the first postoperative day, all patients underwent a comprehensive ophthalmic examination, including BCVA (measured using a Snellen chart), slit-lamp microscopy (Zeiss), and tonometry (non-contact tonometer; CT-80, Topcon Corporation, Japan) Following these evaluations, all patients underwent vault measurement using an Anterion (Heidelberg Engineering GmbH Max-Jarecki-Str.8 69115 Heidelberg, Germany) device after ICL implantation. An experienced optometrist independently measured the central vault value in the Anterion (Heidelberg Engineering) image and recorded the vault measurement in microns. Additionally, the ACD was obtained from the Anterion image alongside the vault measurement. The vault measurement was centered on the optical axis and appeared as a white dashed line on the screen. The procedure was performed individually for each eye. The same parameters were reassessed on the POD 15. Visual acuity, IOP, ACD, and vault measurements were compared between the POD 1 and 15. The observed changes whether an increase, decrease, or stable were analyzed in relation to vault changes to assess the patient's progress, recovery, and the overall effectiveness of the ICL procedure.

This systematic approach ensured that patient selection was precise, preoperative data was comprehensive, and postoperative recovery was properly monitored, which allowed for an effective evaluation of the outcomes of ICL surgery.

Data Analysis

Statistical analysis was performed using R version 4.4.2. and MS-Excel. The categorical variables were summarized by their frequency and percentage distributions, while the continuous variables were summarized by their mean and standard deviation. To compare the change from POD 1 to POD 15, we applied a Wilcoxon W test. For comparisons among groups, we used Fisher's exact test for categorical variables and the Kruskal-Wallis test for continuous variables. A mixed-model binary logistic regression was performed to identify the risk factors associated with the change in lens vault during the first 15 days after surgery.

Results

The study sample consisted of 202 eyes from 101 patients. The participants had a median age of 25 ± 5 years, with a higher proportion of males than females. Specifically, there were 61 males (60.40%) and 40 females (39.60%), indicating a relatively young and concentrated sample. Refractive error parameters, such as spherical equivalents (SE OD: -8.25±5.5 D; SE OS: -8.00±5.5 D), indicated high myopia, with a wide range (e.g., from -25.3 D to +13.8 D), highlighting significant variability in refractive status. BCVA was generally good (median = 0), although some patients exhibited values up to 0.6 logMAR. IOP increased from pre-op levels (median = 13 mmHg) to POD 1 (15 mmHg), then slightly decreased by POD 15 (14 mmHg), with broad interquartile ranges and maximum values reaching up to 41 mmHg. Lens vault and ACD values showed notable variability, with extensive ranges in lens vault measurements (e.g., 180–1600 microns), indicating considerable anatomical diversity across eyes and time points.

The Shapiro-Wilk p-values indicate that most variables significantly deviate from a normal distribution ($p<0.05$), such as age, refractive components (SPH, CYL), BCVA, and IOP. The Wilcoxon W test analysis (Table 1) comparing ocular parameters between POD 1 and 15 revealed significant short-term improvements following the intervention. Lens vault had decreased significantly (mean difference = 50.5 microns, $p<0.001$), indicating possible anterior chamber deepening. ACD had increased significantly (mean difference=0.0399 mm, $p<0.001$), and IOP had shown a highly significant reduction (mean difference=1.5 mmHg, $p<0.001$), both reflecting effective anatomical remodeling. A modest but statistically significant improvement in BCVA was also observed (mean difference=0.05, $p=0.041$), suggesting enhanced post-operative visual outcomes.

A Fisher's exact test was used to classify lens vaults as low (<250 µm), moderate (250–749 µm), or high (≥750 µm), with moderate vault considered the ideal post-ICL outcome. Low vaults may lead to lens-ICL contact and cataract risk, while high vaults can increase the risk of angle closure and glaucoma. Changes in these categories from POD 1 to 15 reflect the stability or variability in ICL positioning. On POD 1, the majority of patients (52.5%) had a moderate lens vault, while 39.1% had a high vault, and 8.40% fell into the low category. By postoperative day 15, the proportions remained largely consistent, with 59.41% still in the moderate range, 30.20% in the high category, and 10.40% in the low category. However, individual transitions between categories provide deeper insight into lens vault stability (Figure 1).

Among patients with a low vault on POD 1, 94.12% remained in the low category on POD 15, while 5.88% shifted to the high category. This suggests that low vaults tend to remain low over time. For those with a moderate lens vault on postoperative day-1, 95.28% remained in the same category on POD 15, while a small proportion (3.77%) shifted to the low vault category and an even smaller percentage (0.94%) moved to the high vault category. Among those with a high vault, 74.68% remained stable, but 24.05% transitioned to the moderate category and 1.27% moved to the low category. The change in the distributions of low, moderate, and high vaults on POD 1 and 15 were statistically significant. This implies that, for the majority of patients, the lens vault categories do not change. However, a small proportion of moderate vaults and a considerable proportion of high vaults tend to decrease over time (Table 2).

Although lens vault categories tend to remain unchanged over the first 15 days, the measurement of lens vault clearly shows that in 75.2% of eyes (152/202), the vault decreased (95% CI: 69.8%–81.4%), in 22.8% of eyes (46/202), it increased (95% CI: 17.3%–29.0%), and only 2% of eyes (4/202), the vault measurements remained unchanged (95% CI: 0%–8.2%). The magnitude of the decrease or increase might not have been sufficient to cause a shift between the categories of low, moderate, and high (Figure 2).

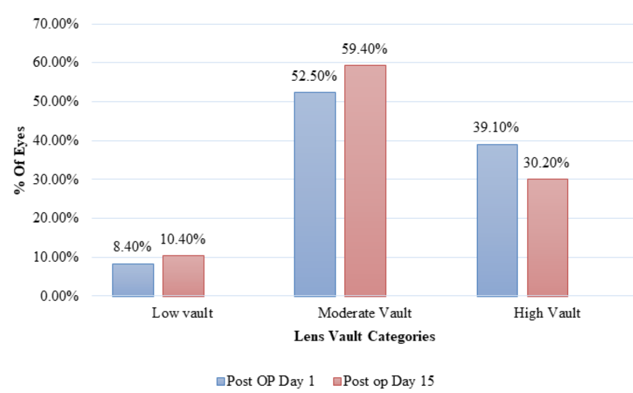

Figure 1: Transition of lens vault in different categories for post op day 1 to day 15

Table 1: Change in the lens vault and other relevant parameters from POD 1 to POD 15

		p	*Mean difference*	*SE difference*	*95% CI Lower*	*95% CI Upper*
POD 1 Lens Vault (µm)	POD 15 Lens Vault (µm)	<.001	50.5	8.19608	40.4999	60.5001
POD1 ACD (mm)	POD 15 ACD (mm)	<.001	0.0399	0.00563	0.02	0.055
POD 1 IOP (mmHg)	POD 15 IOP (mmHg)	<.001	1.5	0.34758	1	2.5
POD 1 BCVA	POD 15 BCVA	0.041	0.05	0.012	0.01	0.1

Table 2: Transition of lens vaults categories (Day 1 to Day 15)

	Lens Vault Category (POD 15)			
Lens Vault Category (POD 1)	*low (<250)*	*Moderate (>=250 and <750)*	*high (>=750)*	*Total*
low (<250)	16 (94.12)	0 (0.00)	1 (5.88)	17 (8.42)
moderate (>=250 and <750)	4 (3.77)	101 (95.28)	1 (0.94)	106 (52.48)
high (>=750)	1 (1.27)	19 (24.05)	59 (74.68)	79 (39.11)
Total	21 (10.40)	120 (59.41)	61 (30.20)	202

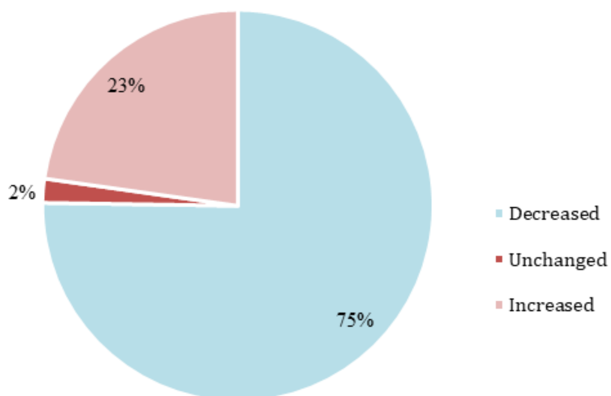

Figure 2: Overall Lens vault changes

There was no statistically significant difference between genders in terms of lens vault changes, as indicated by a Fisher's exact test value of 0.859. This suggests that gender does not play a meaningful role in influencing post-operative lens vault stability. Pre-operative IOP, ACD, and vision (LogMAR) showed no significant association with postoperative lens vault changes, with p-values of 1.000 and 0.695, respectively, indicating minimal impact on vault behavior. However, myopia severity significantly influenced vault changes (p=0.006). High myopia was linked to more frequent vault reduction (80%), while moderate myopia often led to increases (61.54%). Mild myopia showed mixed results. These findings suggest that greater myopic correction may promote better ICL settling and greater vault reduction. The quantified refractive error also showed similar patterns in the lens vault change. Spherical dioptre and SE showed statistically significant differences across the groups. Eyes with a decrease in lens vault had an average sphere of -9.09±4.44D, those with an unchanged vault had an average of -11.56 ± 4.26D, and those with an increase had an average of -5.97±3.39D (p=0.000). Similarly, the SE showed an average of -9.90±4.50D in the decreased group, -11.84±3.25D in the unchanged group, and -6.61±3.47D in the increased group (p=0.000). This indicates that larger myopic correction is more closely associated with a decrease in lens vault (Table 3).

A mixed-model multivariable logistic regression revealed SE as the only significant independent predictor of lens vault decrease within 15 days post-surgery (p<0.001), with higher myopia associated with greater reduction. ACD did not show significant changes. These findings align with univariate analysis, emphasizing refractive error as the key factor in early vault changes, while accounting for individual variability through a random effect (Table 4).

Discussion

This study analyzed both preoperative and early postoperative outcomes of ICL implantation in 202 eyes, offering valuable observations on vault stability within the first 15 days after surgery. Previous research has consistently shown that the ICL V4c model delivers safe, effective, and predictable visual correction for patients with myopia and astigmatism (Miao H et al., 2018; Alfonso JF et al., 2010). Additionally, several investigations have indicated a gradual decline in ICL vault over time (Schmidinger G et al., 2010; Huseynova T et al., 2014). Despite these findings, there remains limited literature exploring the variables influencing vault fluctuations. A number of studies have sought to refine the prediction of optimal vault by examining contributing factors, proposing improved sizing methods, and developing predictive models for postoperative vault outcomes (Chen X et al., 2016; Shen Y et al., 2023; Choi KH et al., 2007).

In this cohort, vault measurements changed significantly between the POD 1 and 15. The analysis revealed a notable reduction in lens vault (mean difference=50.5 µm, SE=8.20, p<0.001; 95% CI=40.5 to 60.5 µm). Previous reports observed a substantial drop in vault between 2 hours and 1 day post-implantation, followed by an increase within the first week; however, by one month post-surgery, vault values remained lower than the initial 2-hour readings (Zhu QJ et al., 2021). Only a few studies have documented vault dynamics within the first 24 hours after surgery (Chen X et al., 2016). One study also highlighted an increased risk of anterior sub-capsular cataract formation when the vault measured below 0.09 mm (Gonvers M, Bornet C, Othenin-Girard P 2003).

Moreover, ACD in this study exhibited a statistically significant increase (mean difference = 0.0399 mm, SE=0.00563D, p<0.001; 95% CI=0.02 to 0.055 mm). Prior research has suggested a greater vault reduction over time in eyes with shallower ACDs, possibly due to increased

Table 3: Pre-operative factors influencing lens vault changes

	Change in lens vault from day-1 to day-15			*Total*	*p-value*
	Decreased	*Unchanged*	*Increased*		
Total Responses	152 (75.25)	4 (1.98)	46 (22.77)	202	
Myopia					
High	120 (80.00)	4 (2.67)	26 (17.33)	150	0.006*
Mild	5 (38.46)	0 (0.00)	8 (61.54)	13	
Moderate	27 (69.23)	0 (0.00)	12 (30.77)	39	
Pre-Op IOP					
Normal	152 (75.25)	4 (1.98)	46 (22.77)	202	
ACD					
Deep	36 (80.00)	1 (2.22)	8 (17.78)	45	0.695*
Normal	115 (73.72)	3 (1.92)	38 (24.36)	156	
Shallow	1	0 (0.00)	0 (0.00)	1	
Continuous Variables					
Age	25.59 ± 4.08	26.25 ± 2.75	25.07 ± 3.33	25.49 ± 3.90	0.675**
Sph	-9.09 ± 4.44	-11.56 ± 4.26	-5.97 ± 3.39	-8.43 ± 4.42	0.000**
Cyl	-1.63 ± 1.40	-0.56 ± 3.12	-1.27 ± 1.24	-1.53 ± 1.42	0.356**
SE	-9.90 ± 4.50	-11.84 ± 3.25	-6.61 ± 3.47	-9.19 ± 4.48	0.000**
Pre-Op LogMAR	0.06 ± 0.11	0.00 ± 0.00	0.06 ± 0.10	0.06 ± 0.11	0.484**
PreOp IOP	13.95 ± 2.64	14.00 ± 2.94	13.80 ± 2.42	13.92 ± 2.59	0.992**
PreOp ACD	3.26 ± 0.29	3.12 ± 0.36	3.28 ± 0.21	3.26 ± 0.27	0.496**

Note: Figures in parentheses are percentages. Continuous variables have been expressed by mean ± SD. * indicates Fisher's exact test, ** indicates Kruskal-Wallis test.

pressure exerted by the iris on the ICL in these cases.[21] IOP also demonstrated a significant decline post-operatively (mean difference=1.5 mmHg, SE = 0.34758D, p < 0.001; 95% CI=1 to 2.5 mmHg). Although transient IOP elevation after ICL implantation is commonly observed, it is generally manageable without long-term complications. Recognizing the mechanisms of IOP fluctuation is essential to avoid vision-threatening outcomes like glaucoma (Senthil S et al., 2017). In the present study, IOP stabilized during follow-up, and none of the patients required anti-glaucoma medications. Additionally, a slight but meaningful improvement in BCVA was recorded, with a mean gain of 0.05 (SE=0.012, p=0.041; 95% CI= 0.01 to 0.1). Supporting this, previous research found that both uncorrected and corrected distance visual acuity significantly improved one month after surgery, with stability in visual outcomes at later follow-up visits (Lee J et al., 2016).

On POD 1, most patients had a moderate vault (52.5%), with similar distributions observed by day 15. While categorical stability was high especially in low (94.12%) and moderate (95.28%) vault groups, some high vaults (25.32%) shifted to lower categories. Overall, 75.2% of eyes showed a decrease in vault size, 22.8% an increase, and 2% remained unchanged, indicating that although most vaults remained within the same category, subtle anatomical changes occurred in the first two weeks post-surgery.

Table 4: Results of multivariable analysis

Factors	*OR*	*p-value*
(Intercept)	2.06	0.820
SE	0.82	<0.001
Pre Op ACD (mm)	0.59	0.508

The statistical analysis found no significant association between changes in lens vault from POD 1 to 15 and preoperative IOP, or ACD. Pre-op IOP (p=1.000) and ACD (p=0.695) also showed no significant impact, with consistent vault change patterns across all groups. These findings are consistent with those of a prior study by (Li B et al., 2003) which also reported no significant correlations between vault decrease and preoperative ACD or IOP. The degree of myopia significantly influenced post-op vault behavior (p=0.006). High myopia was associated with greater vault reduction (80%), while moderate myopia more often showed an increase (61.54%). A previous study similarly found that higher myopia was associated with a greater number of eyes with high vault, while lower myopia was more prevalent in cases with low vault (Cerpa Manito S et al., 2021). Further supporting this, analysis of SE revealed that patients with decreased vaults had significantly higher myopia (-9.90±4.50D) compared to those with increased vaults (-6.61±3.47D), with a highly significant p-value (0.000). This indicates that greater myopia is associated with more pronounced vault reduction, likely due to anatomical variations in highly myopic eyes. While most biometric factors had no effect, myopia severity stood out as a key predictor of early postoperative vault changes, offering valuable insight for preoperative planning.

A mixed-model multivariate logistic regression revealed SE as the only significant independent predictor of lens vault decrease within 15 days post-surgery ($p<0.001$), with higher myopia associated with greater reduction. ACD showed no significant changes. Other factors, such as ICL rotation, change of fixed location, physiologic or accommodative pupillary movement, and age-related increases in crystalline lens thickness, also account for the decrease in ICL vault over time (Kamiya K et al., 2009; Kamiya K et al., 2009). The study had some limitations. The 15-day follow-up period allowed assessment of early vault changes but did not capture long-term outcomes. Manual vault measurements, though performed by an experienced optometrist using a standardized protocol, may have introduced minor variability. Accommodation and pupil size were not specifically controlled but measurements were conducted under consistent lighting. As a single-center study with a young, myopic population, generalizability may be limited, though internal validity was maintained.

Conclusions

High degrees of myopic correction are significantly associated with a greater reduction in lens vault during the initial 15 days following ICL implantation. The findings underscore the predictive value of preoperative myopia severity on early postoperative vault changes and highlight the importance of vigilant patient monitoring to ensure optimal surgical outcomes. Important biometric factors like axial length and white-to-white distance were not included and should be considered in future studies to enhance predictive accuracy.

References

Alfonso, J. F., Fernandez-Vega, L., Lisa, C., Fernandes, P., González-Meijome, J., & Montés-Micó, R. (2012). Long-term evaluation of the central vault after phakic Collamer® lens (ICL) implantation using OCT. *Graefe's Archive for Clinical and Experimental Ophthalmology, 250*(12), 1807–1812.

Alfonso, J. F., Lisa, C., Abdelhamid, A., Fernandes, P., Jorge, J., & Montés-Micó, R. (2010). Three-year follow-up of subjective vault following myopic implantable Collamer lens implantation. *Graefe's Archive for Clinical and Experimental Ophthalmology, 248*(12), 1827–1835.

Cerpa Manito, S., Sánchez Trancón, A., Torrado Sierra, O., Baptista, A. M., & Serra, P. M. (2021). Biometric and ICL-related risk factors associated to sub-optimal vaults in eyes implanted with implantable Collamer lenses. *Eye and Vision, 8*(1), 26.

Chen, X., Miao, H., Naidu, R. K., Wang, X., & Zhou, X. (2016). Comparison of early changes in and factors affecting vault following posterior chamber phakic implantable Collamer lens implantation without and with a central hole (ICL V4 and ICL V4c). *BMC Ophthalmology, 16*(1), 161.

Choi, K. H., Chung, S. E., Chung, T. Y., & Chung, E. S. (2007). Ultrasound biomicroscopy for determining Visian implantable contact lens length in phakic IOL implantation. *Journal of Refractive Surgery, 23*(4), 362–367.

Fernandes, P., González-Méijome, J. M., Madrid-Costa, D., Ferrer-Blasco, T., Jorge, J., & Montés-Micó, R. (2011). Implantable Collamer posterior chamber intraocular lenses: A review of potential complications. *Journal of Refractive Surgery, 27*(10), 765–776.

Gonvers, M., Bornet, C., & Othenin-Girard, P. (2003). Implantable contact lens for moderate to high myopia: Relationship of vaulting to cataract formation. *Journal of Cataract & Refractive Surgery, 29*(5), 918–924.

Huseynova, T., Ozaki, S., Ishizuka, T., Mita, M., & Tomita, M. (2014). Comparative study of two types of implantable Collamer lenses, one with and one without a central artificial hole. *American Journal of Ophthalmology, 157*(6), 1136–1143.

Igarashi, A., Shimizu, K., & Kamiya, K. (2014). Eight-year follow-up of posterior chamber phakic intraocular lens implantation for moderate to high myopia. *American Journal of Ophthalmology, 157*(3), 532–539.

Kamiya, K., Shimizu, K., & Kawamorita, T. (2009). Changes in vaulting and the effect on refraction after phakic posterior chamber intraocular lens implantation. *Journal of Cataract & Refractive Surgery, 35*(9), 1582–1586.

Kamiya, K., Shimizu, K., & Komatsu, M. (2009). Factors affecting vaulting after implantable Collamer lens implantation. *Journal of Refractive Surgery, 25*(3), 259–264.

Koch, D. D., Samuelson, S. W., Villarreal, R., Haft, E. A., & Kohnen, T. (1996). Changes in pupil size induced by phacoemulsification and posterior chamber lens implantation: Consequences for multifocal lenses. *Journal of Cataract & Refractive Surgery, 22*(5), 579–584.

Lee, H., Kang, S. Y., Seo, K. Y., Chung, B., Choi, J. Y., Kim, K. S., et al. (2014). Dynamic vaulting changes in V4c versus V4 posterior chamber phakic lenses under differing lighting conditions. *American Journal of Ophthalmology, 158*(6), 1199–1204.

Lee, J., Kim, Y., Park, S., Bae, J., Lee, S., Park, Y., et al. (2016). Long-term clinical results of posterior chamber phakic intraocular lens implantation to correct myopia. *Clinical & Experimental Ophthalmology, 44*(6), 481–487.

Li, B., Chen, X., Cheng, M., Lei, Y., Jiang, Y., Xu, Y., et al. (2023). Long-term vault changes in different levels and factors affecting vault change after implantation of implantable Collamer lens with a central hole. *Ophthalmology and Therapy, 12*(1), 251–261.

Lindland, A., Heger, H., Kugelberg, M., & Zetterström, C. (2010). Vaulting of myopic and toric implantable Collamer lenses during accommodation measured with Visante optical coherence tomography. *Ophthalmology, 117*(6), 1245–1250.

Marchini, G., Pedrotti, E., Sartori, P., & Tosi, R. (2004). Ultrasound biomicroscopic changes during accommodation in eyes with accommodating intraocular lenses: Pilot study and hypothesis for the mechanism of accommodation. *Journal of Cataract & Refractive Surgery, 30*(12), 2476–2482.

Miao, H., Chen, X., Tian, M., Chen, Y., Wang, X., & Zhou, X. (2018). Refractive outcomes and optical quality after implantation of posterior chamber phakic implantable Collamer lens with a central hole (ICL V4c). *BMC Ophthalmology, 18*(1), 141.

Neri, A., Ruggeri, M., Protti, A., Leaci, R., Gandolfi, S. A., & Macaluso, C. (2015). Dynamic imaging of accommodation by swept-source anterior segment optical coherence tomography. *Journal of Cataract & Refractive Surgery, 41*(3), 501–510.

Petternel, V., Köppl, C. M., Dejaco-Ruhswurm, I., Findl, O., Skorpik, C., & Drexler, W. (2004). Effect of accommodation and pupil size on the movement of a posterior chamber lens in the phakic eye. *Ophthalmology, 111*(2), 325–331.

Schmidinger, G., Lackner, B., Pieh, S., & Skorpik, C. (2010). Long-term changes in posterior chamber phakic intraocular Collamer lens vaulting in myopic patients. *Ophthalmology, 117*(8), 1506–1511.

Senthil, S., Choudhari, N. S., Vaddavalli, P. K., Murthy, S., Reddy, J. C., & Garudadri, C. S. (2017). Correction: Etiology and management of raised intraocular pressure following posterior chamber phakic intraocular lens implantation in myopic eyes. *PLoS ONE, 12*(2), e0172929.

Serra, P., Sánchez Trancón, Á., Torrado Sierra, O., Baptista, A., & Cerpa Manito, S. (2021). Posterior chamber phakic intraocular lenses for the correction of myopia: Factors influencing the postoperative refraction. *Optics, 2*(4), 292–305.

Shen, Y., Wang, L., Jian, W., Shang, J., Wang, X., Ju, L., et al. (2023). Big-data and artificial-intelligence-assisted vault prediction and EVO-ICL size selection for myopia correction. *British Journal of Ophthalmology, 107*(2), 201–206.

Uusitalo, R. J., Aine, E., Sen, N. H., & Laatikainen, L. (2002). Implantable contact lens for high myopia. *Journal of Cataract & Refractive Surgery, 28*(1), 29–36.

Wang, X., & Zhou, X. (2016). Update on treating high myopia with implantable Collamer lenses. *Asia-Pacific Journal of Ophthalmology (Phila), 5*(6), 445–449.

Zhu, Q. J., Chen, W. J., Zhu, W. J., Xiao, H. X., Zhu, M. H., Ma, L., et al. (2021). Short-term changes in and preoperative factors affecting vaulting after posterior chamber phakic implantable Collamer lens implantation. *BMC Ophthalmology, 21*(1), 199.