• Clinical Research •

Comparison of three different instruments for vault measurements after implantable collamer lens implantation

Bo-Liang Li[1,2], Ming-Rui Cheng[1,3,4,5], Wei-Teng Chang[1,3,4,5], Ya-Di Lei[1,3,4,5], Guang-Han Xu[1,3,4,5], Ming-Wei Li[1,3,4,5], Zhi-Wei Mao[1,3,4,5], Xun Chen[1,3,4,5], Xiao-Ying Wang[1,3,4,5]

[1]Fudan University Eye Ear Nose and Throat Hospital, Shanghai 200031, China
[2]Department of Ophthalmology, Sichuan Provincial People's Hospital, University of Electronic Science and Technology of China, Chengdu 610072, Sichuan Province, China
[3]Key Laboratory of Myopia and Related Eye Diseases, NHC and Chinese Academy of Medical Sciences, Shanghai 200031, China
[4]Shanghai Research Center of Ophthalmology and Optometry, Shanghai 200031, China
[5]State Key Laboratory of Medical Neurobiology and MOE Frontiers Center for Brain Science, Fudan University, Shanghai 200031, China
Co-first Authors: Bo-Liang Li and Ming-Rui Cheng
Correspondence to: Xiao-Ying Wang and Xun Chen. Fudan University Eye Ear Nose and Throat Hospital, No.19 Baoqing Road, XuHui District, Shanghai 200031, China. doctxiaoyingwang@163.com; chenxun19910923@163.com
Received: 2025-02-07 Accepted: 2025-06-19

Abstract

• **AIM:** To evaluate the differences and consistency of vault measurements obtained by Scheimpflug tomography (Pentacam), anterior segment optical coherence tomography (AS-OCT, CASIA II), and ultrasound biomicroscopy (UBM) following implantable collamer lens (ICL) V4c implantation.

• **METHODS:** Vault measurements were acquired using three modalities: Pentacam, CASIA II AS-OCT, and UBM. Repeated-measures analysis of variance was used to compare the vault values obtained by the three devices. The correlation and consistency of measurements among the three instruments were assessed using the Pearson correlation coefficient, intraclass correlation coefficient (ICC), and Bland-Altman plots.

• **RESULTS:** This retrospective study enrolled 210 myopic eyes of 210 patients (158 women and 52 men) who underwent ICL implantation: 108 eyes had a myopic ICL V4c implanted, and 102 eyes had a toric ICL V4c implanted. The mean vault values measured by Pentacam, CASIA II, and UBM were 452.64±204.20 μm, 538.57±203.54 μm, and 560.95±227.54 μm, respectively, with statistically significant differences among the three groups (P<0.05). Pearson correlation analysis showed strong positive correlations between vault values measured by different instruments (all P<0.001). ICC results indicated good consistency among the three measurement modalities (all P<0.001). Stratified analysis revealed that when the vault value was ≤250 μm, the correlation and consistency of measurements across the three instruments were lower than those in the medium and high vault subgroups.

• **CONCLUSION:** Vault values measured by Pentacam are lower than those obtained by CASIA II and UBM, with UBM yielding the highest mean vault values. Measurements from the three instruments are not interchangeable but can serve as mutual references due to their significant correlation and good overall consistency. Pentacam and CASIA II demonstrate the highest consistency in vault measurement. Notably, when the vault value is ≤250 μm, the consistency between Pentacam and the other two instruments decreases significantly.

• **KEYWORDS:** implantable collamer lens; vault measurement; scheimpflug tomography; anterior segment optical coherence tomography; ultrasound biomicroscopy; measurement consistency

DOI:10.18240/ijo.2026.03.07

Citation: Li BL, Cheng MR, Chang WT, Lei YD, Xu GH, Li MW, Mao ZW, Chen X, Wang XY. Comparison of three different instruments for vault measurements after implantable collamer lens implantation. *Int J Ophthalmol* 2026;19(3):475-482

INTRODUCTION

The Vision Implantable Collamer Lens (ICL, STAAR Surgical Co., USA) is the most widely-used phakic intraocular lens worldwide and is demonstrated to be safe and effective for myopia and astigmatism correction[1-3]. The ICL

is placed in the posterior chamber and protrudes anteriorly to form a gap between the ICL and crystalline lens. The distance between the posterior surface of the ICL and the anterior surface of the crystalline lens is called the vault and plays a vital role in procedural safety. A low vault may lead to mechanical contact with the crystalline lens or alterations in aqueous humor dynamics, which increases the risk of cataract formation[4-5]. An excessively high vault causes mechanical contact between the ICL and iris and alterations in aqueous humor dynamics, resulting in inflammation, high intraocular pressure, angle-closure glaucoma, pigment dispersion syndrome, and corneal endothelial dysfunction[6-7]. A central vault ranging from 250 to 750 μm is generally considered sufficient to ensure the safety of the procedure[8].

The vault is a crucial parameter after ICL implantation, and the measured value may affect the surgeon's decision-making. Changing the ICL size or performing rotational adjustments may need to be considered for patients with a persistent vault value above 1000 or below 100 μm[9-10]. However, a second surgery may cause a reduction in the corneal endothelium or cause intraocular trauma. Therefore, an accurate measurement of the vault is particularly important. The vault is constantly changing and not a static parameter. Even measurements taken on the same day are affected by light-induced changes in pupil size[11-13] and different instrument usage[14-15]. The vault proportionally increases and decreases with the change of pupil size[11-13]; the vault measurement also varies when measured by different instruments and is higher than that measured by Scheimpflug tomography (Pentacam) when measured by anterior segment optical coherence tomography (AS-OCT)[14]. Moreover, the vault tends to decrease over time[16], and the size of the vault affects postoperative refractive error[17]. Therefore, the accurate measurement and evaluation of vaults is worth exploring.

Currently, three main types of equipment are used to measure the vault: AS-OCT, Pentacam, and ultrasound biomicroscopy (UBM). Although many studies have evaluated vault measurements after ICL implantation using these techniques, few have assessed the differences and consistency in vault measurements between these devices[14,18]. To our knowledge, the agreement between vault measurements has not yet been examined using CASIA II. This study was designed to evaluate the differences and consistency in measuring the vault after ICL implantation using three anterior-segment imaging systems: CASIA II, Pentacam, and UBM. We hope to provide a reference to choose different devices to measure vault after ICL implantation and how to judge vault results measured by different devices to improve the prognosis and safety after surgery.

PARTICIPANTS AND METHODS

Ethical Approval This study adhered to the Declaration of Helsinki and was approved by the Ethics Committee of the Fudan University Eye and ENT Hospital (Approval Number: 2021018). Written informed consent was obtained from all patients after the possible consequences of the study were explained.

ICL Power Calculation and Size Selection ICL power was calculated using the software provided by the manufacturer (STAAR Surgical). The size of the implanted ICL was selected based on the patient's anterior chamber depth and white-to-white value measured using corneal tomography (Pentacam AXL, Oculus, Germany). UBM measurements such as sulcus-to-sulcus distance were used to determine whether the size needed adjustment[19].

Surgical Technique The ICL V4c implantation procedures for all included patients were performed by an experienced surgeon (Wang XY) using a one-step technique as previously described[20]. Before surgery, pupils were dilated with 2.5% phenylephrine and 1% tropicamide. An injector cartridge was used to insert the lens *via* a 3-mm temporal corneal incision. A moderately viscoelastic surgical agent was injected into the anterior chamber, followed by the placement of the lens in the posterior chamber, and afterward, the viscoelastic surgical agent was washed away using a balanced salt solution. Postoperative medications included antibiotic eye drops, non-steroidal anti-inflammatory eye drops, steroidal eye drops, and artificial tears.

Vault Measurement The vault was measured 6mo postoperatively using the CASIA II, Pentacam, and UBM. The vault was measured three times and averaged. CASIA II and Pentacam assessments were performed in the same room under dark conditions, while UBM was conducted in a standard illuminated room. Horizontal median images were captured for analysis to avoid eyelid influence. The vault was measured as the central vertical distance from the back surface of the ICL to the anterior surface of the crystalline lens (Figure 1). Vault measurements were obtained from the images using built-in software and measurement tools provided by the manufacturers.

The CASIA II (Tomey Corporation, Nagoya, Japan) is a swept-source fourier-domain AS-OCT system providing quantitative measurements of the anterior segment structure. It uses a wavelength of 1310 nm with a maximum penetration depth of 13 mm and measures 50 000 axial scans per second[21-22]. CASIA II has excellent repeatability and reproducibility in ocular biometry[21,23]. Good agreement for anterior segment values has been demonstrated between CASIA II and other swept-source OCT devices or Scheimpflug cameras[24-26]. In addition to the software's built-in calipers, CASIA II also provides a phakic intraocular lens module within the 2D analysis software for vault measurement.

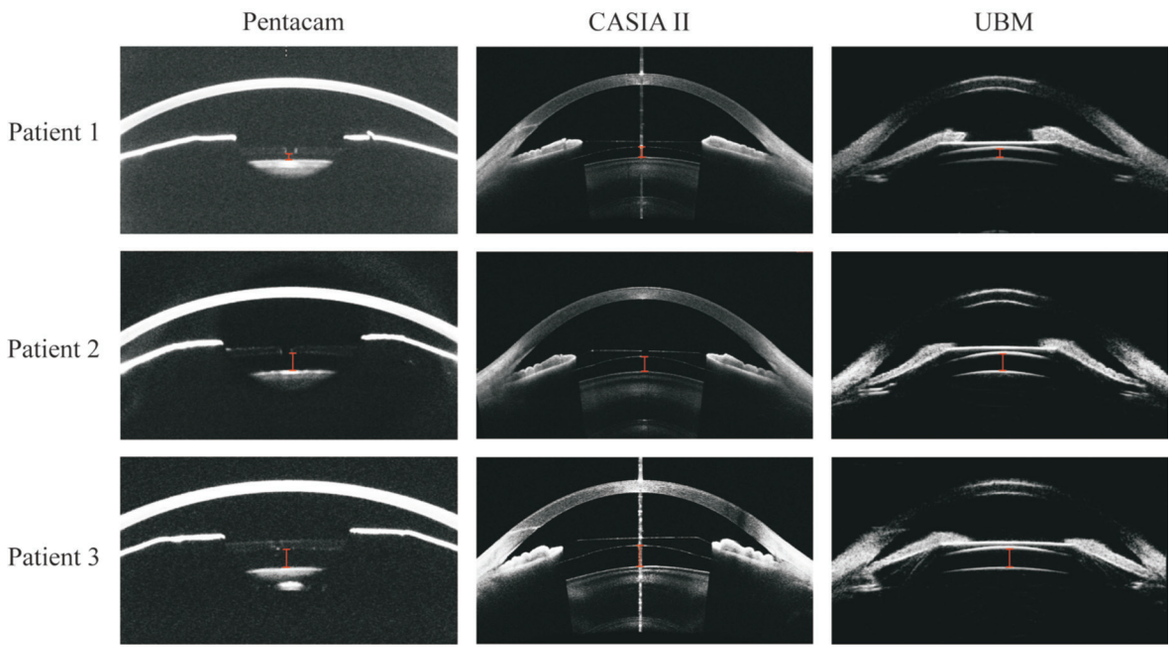

Figure 1 Vault measured using Pentacam, CASIA II, and ultrasound biomicroscopy (UBM) after ICL V4c implantation Patient 1: Pentacam 240 μm, CASIA II 417 μm, UBM 450 μm; Patient 2: Pentacam 570 μm, CASIA II 653 μm, UBM 810 μm; Patient 3: Pentacam 760 μm, CASIA II 783 μm, UBM 850 μm. Vault: Orange double-headed arrow.

The Pentacam (Oculus, Germany) is a rotating Scheimpflug camera that captures 100 Scheimpflug images and obtains 138 000 elevation data points, which are processed to reconstruct the entire cross-section of the anterior segment. Vault values were measured in horizontal overview images using calipers provided by the Pentacam software[27].

UBM (Quantel Medical, Clermont-Ferrand, France) was performed in a standard illumination room using a 50-MHz transducer probe with patients in the supine decubitus position. After topical anesthesia, an orbital cup was inserted with a blepharostat. Images of the horizontal anterior segment were acquired by keeping the probe perpendicular to the horizontal limbus and avoiding pressing the eyeball. Vault values were obtained from horizontal overview images using the software's built-in calipers.

Statistical Analysis All statistical analyses were performed using SPSS version 20.0 (SPSS Corp., Armonk, NY, USA), and the results are expressed as means±standard deviations (SD). The differences between the devices in vault measurements were examined using repeated-measures analysis of variance (ANOVA) with post hoc Bonferroni correction for multiple comparisons. The correlation between the vault values measured using different instruments was evaluated using the Pearson correlation coefficient (*r*). The reliability of the measurements from different instruments was calculated using the intraclass correlation coefficient (ICC) for consistency. In addition, the agreement between the measurement procedures was assessed using a Bland-Altman plot. The variability of vault values was described as the 95% limits of agreement (95% LOA=mean±1.96 SD). *P* values less than 0.05 were considered statistically significant.

Table 1 Preoperative data and parameters of the implanted ICL lenses

Parameters	Mean±SD	Range (min, max)
Spherical error (D)	-8.20±2.56	-19.00, -1.75
Cylinder (D)	-1.19±0.92	-5.00, 0.00
ICL size (mm)	12.78±0.40	12.1, 13.7
ICL power (D)	-10.17±2.70	-18.00, -3.50
White-to-white (mm)	11.57±0.33	10.5, 12.4
ACD (mm)	3.22±0.23	2.75, 3.83

ACD: Anterior chamber depth; ICL: Implantable Collamer lens; SD: Standard deviation.

RESULTS

Participants This retrospective study enrolled 210 myopic eyes of 210 patients (158 women and 52 men) who underwent ICL implantation: 108 eyes had a myopic ICL V4c implanted, and 102 eyes had a toric ICL V4c (STAAR Surgical, Co.) implanted. The preoperative data and parameters of the implanted ICL are shown in Table 1.

Comparison of Measurements Between Instruments The average vault values measured using Pentacam, CASIA II, and UBM were 452.64±204.20, 538.57±203.54, and 560.95±227.54 μm, respectively. The vault measurements obtained using the three instruments were significantly different (all $P<0.001$). The vaults measured by Pentacam were significantly lower than those measured by CASIA II and UBM, with UBM having the highest vault measurements.

Consistency Between Different Instruments The Pearson correlation coefficient (Table 2) showed a significant

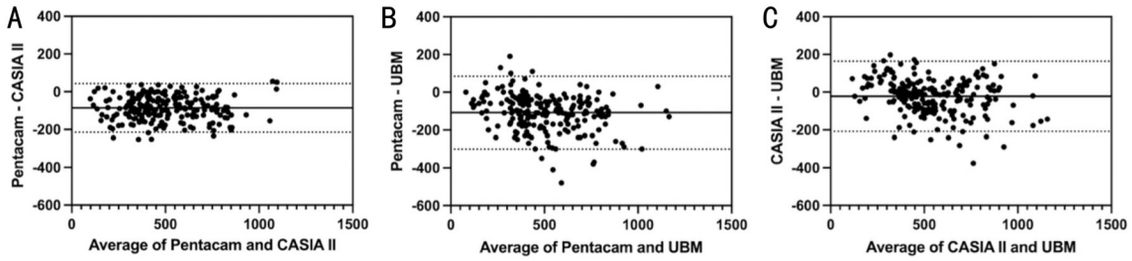

Figure 2 Bland and Altman plots compare the level of agreement between the three instruments for vault measurements The vertical axis represents the difference between these measurements, and the horizontal axis shows their mean value. Dashed lines represent the 95% limits of agreement. The solid line represents the mean difference. All scales are in micrometer.

Table 2 Pearson correlation coefficient, ICC, and agreement of vault values measured by Pentacam, CASIA II, and UBM

Parameter	Pentacam *vs* CASIA II	Pentacam *vs* UBM	CASIA II *vs* UBM
Pearson (*r*)	0.948	0.902	0.909
P_r	<0.001[a]	<0.001[a]	<0.001[a]
ICC (95%CI)	0.948 (0.932 to 0.960)	0.897 (0.867 to 0.920)	0.903 (0.875 to 0.926)
P_{ICC}	<0.001[a]	<0.001[a]	<0.001[a]
Mean±SD	-85.93±65.73	-108.31±98.24	-22.38±94.84
95%CI	-94.87 to -76.99	-121.67 to -94.95	-35.28 to -9.48
LOA	-214.76 to 42.90	-300.85 to 84.23	-208.27 to 163.51

CI: Confidence interval; ICC: Intraclass correlation coefficient; LOA: Limits of agreement; SD: Standard deviation; UBM: Ultrasound biomicroscopy. *P* values less than 0.05 were considered statistically significant; Mean: Mean value of measurement difference between two methods.

correlation between the vault values measured using the three instruments (all $P<0.001$). The ICC for consistency (Table 2) showed that Pentacam had excellent agreement with CASIA II, with an ICC of 0.948. The ICC of Pentacam *vs* UBM and CASIA II *vs* UBM were 0.897 and 0.903, respectively. The results of all three instruments were in good agreement (ICC>0.80). The Bland-Altman plots showed the consistency of the three instruments for vault measurements (Figure 2). The mean differences between measurements from Pentacam, CASIA II, and UBM, together with the 95%LOA, are shown in Table 2.

Consistency between Instruments in Different Vault Levels The eyes were divided into three groups based on the Pentacam vault measurements: Group 1: vault ≤ 250 μm (n=30), Group 2: 250<vault<700 μm (n=150), Group 3: vault ≥ 700 μm (n=30). In Group 1, the consistency of Pentacam *vs* CASIA and Pentacam *vs* UBM were poor (ICC=0.541 and 0.573, respectively), and the consistency of CASIA II and UBM was moderate (ICC=0.646). In Group 2, Pentacam *vs* CASIA had good consistency (ICC=0.876), and Pentacam *vs* UBM and CASIA II *vs* UBM had moderate consistency (ICC=0.734 and 0.793, respectively). In Group 3, the agreement between the three devices was moderate (ICC=0.799, 0.778, and 0.667; Table 3). Table 3 showed that in Group 1, the mean difference of vault measurements between Pentacam and CASIA II was 110.47 μm, which was greater than the mean difference in Groups 2 and 3. The Bland-Altman plots showed the consistency of the three-instrument vault measurements at different vault levels (Figure 3).

DISCUSSION

Since the vault is an indicator closely related to surgical safety, doctors and patients remain concerned about it after ICL implantation[28-30]. Therefore, an instrument to measure the vault should be carefully chosen. This study evaluated the differences and consistency of Pentacam, CASIA II, and UBM in measuring the vault after ICL implantation and provided a reference for the clinical selection of vault measurement equipment and vault size interpretation.

In this study, the vault measurement by CASIA II was (85.93±65.73 μm) higher than that by Pentacam, and the vault measurement by UBM was (22.38±94.84 μm) higher than that by CASIA II. However, there was good agreement among the vault values measured by the three machines. The correlation and agreement between the Pentacam and CASIA II were better than those other combinations, maybe because of the different measurement methods used. Pentacam and CASIA II were automatically positioned by the machine for measurement, while the UBM was manually positioned, and the error was greater owing to factors such as tilt and deviation. Almorín-Fernández-Vigo *et al*[14] also found that the vault values measured using AS-OCT were greater than those measured using Pentacam and were in good agreement with our findings. Wan *et al*[18] also reported that the vault values measured by UBM and AS-OCT were higher than those

Table 3 Pearson correlation coefficient, ICC, and agreement of vault values measured by Pentacam, CASIA II, and UBM in different vault level groups

Groups	Pentacam *vs* CASIA II	Pentacam *vs* UBM	CASIA II *vs* UBM
Group 1 (vault≤250 μm, *n*=30)			
Pearson (*r*)	0.606	0.731	0.665
P_r	<0.001[a]	<0.001[a]	<0.001[a]
ICC (95%CI)	0.541 (0.231 to 0.752)	0.573 (0.274 to 0.771)	0.646 (0.378 to 0.814)
P_{ICC}	0.001[a]	<0.001[a]	<0.001[a]
Mean±SD	-110.47±73.38	-103.93±85.26	6.53±88.84
95%CI	-137.87 to -83.06	-135.77 to -72.10	-26.64 to 39.71
LOA	-254.30 to 33.37	-271.05 to 63.18	-167.59 to 180.66
Group 2 (250 <vault<700 μm, *n*=150)			
Pearson (*r*)	0.880	0.765	0.810
P_r	<0.001[a]	<0.001[a]	<0.001[a]
ICC (95%CI)	0.876 (0.833 to 0.909)	0.734 (0.651 to 0.800)	0.793 (0.725 to 0.846)
P_{ICC}	<0.001[a]	<0.001[a]	<0.001[a]
Mean±SD	-82.31±62.18	-110.45±102.88	-28.13±93.69
95%CI	-92.35 to -72.28	-127.04 to -93.85	-43.25 to -13.02
LOA	-204.18 to 39.55	-312.09 to 91.19	-211.77 to 155.51
Group 3 (vault≥700 μm, *n*=30)			
Pearson (*r*)	0.804	0.792	0.698
P_r	<0.001[a]	<0.001[a]	<0.001[a]
ICC (95%CI)	0.799 (0.620 to 0.899)	0.778 (0.584 to 0.888)	0.667 (0.409 to 0.827)
P_{ICC}	<0.001[a]	<0.001[a]	<0.001[a]
Mean±SD	-79.47±71.80	-102.00±88.41	-22.53±103.89
95%CI	-106.28 to -52.66	-135.01 to -68.99	-61.33 to 16.26
LOA	-200.2 to 48.8	-319.8 to 95.1	-225.7 to 152.5

CI: Confidence interval; ICC: Intraclass correlation coefficient; LOA: Limits of agreement; SD: Standard deviation; UBM: Ultrasound biomicroscopy. *P*-value was set at *P*<0.05; Mean: Mean value of measurement difference between the two methods.

measured by the Pentacam; however, the vaults measured by AS-OCT were higher than those measured by UBM, which differs from our study. However, AS-OCT (Model 1000, Carl Zeiss Meditec, USA) they used was a temporal domain device, which has a lower resolution than the fourier-domain OCT employed in our study. The mean difference between the vaults measured by AS-OCT and Pentacam in Almorín-Fernández-Vigo *et al*[14] and Wan *et al*'s[18] study were 128.1 and 210 μm, respectively, compared to 85.93±65.73 μm in our study, smaller than the previous studies, which may be related to the different AS-OCT we used[14,18].

Several factors may explain the differences in vault measurements between devices. First, the pupil size affects the vault size. The pupil size and vault also varied because of the different light sources used when measuring with different instruments. The blue light used in the Pentacam was visible, whereas the near-infrared light in OCT was not. Bright light induces pupillary constriction and increases the pressure posterior to the iris, pushing it onto the anterior surface of the ICL, resulting in a vault decrease. The pupil was larger when measured by AS-OCT than by Pentacam; correspondingly, the vault was higher[14]. A recent study found that lens changes were also a significant factor influencing vault changes under dark-to-light conditions[13]. Second, the Pentacam has a lower resolution, and the vault is measured at 10 μm intervals, reducing the accuracy of the measurement. For UBM measurement, it is necessary to make the probe perpendicular to the corneal surface as much as possible; the ICL is in the center of the image, and probe tilt or deviation will cause measurement errors. The compression of the eye wall by saline in the eye cup, the ICL positional change caused by the difference between sitting and supine positions, and the difference in accommodative status due to different fixation targets during UBM measurements can all lead to differences in the vault values measured by UBM and other devices. Therefore, Pentacam is more relevant and consistent with CASIA II than UBM.

When the vault is low, its measurement becomes difficult and has a sizable error owing to the limitation of Pentacam resolution, whereas the measurement remains evident and accurate on AS-OCT and UBM. Almorín-Fernández-Vigo *et al*[14] also reported that when there seems to be a crystalline

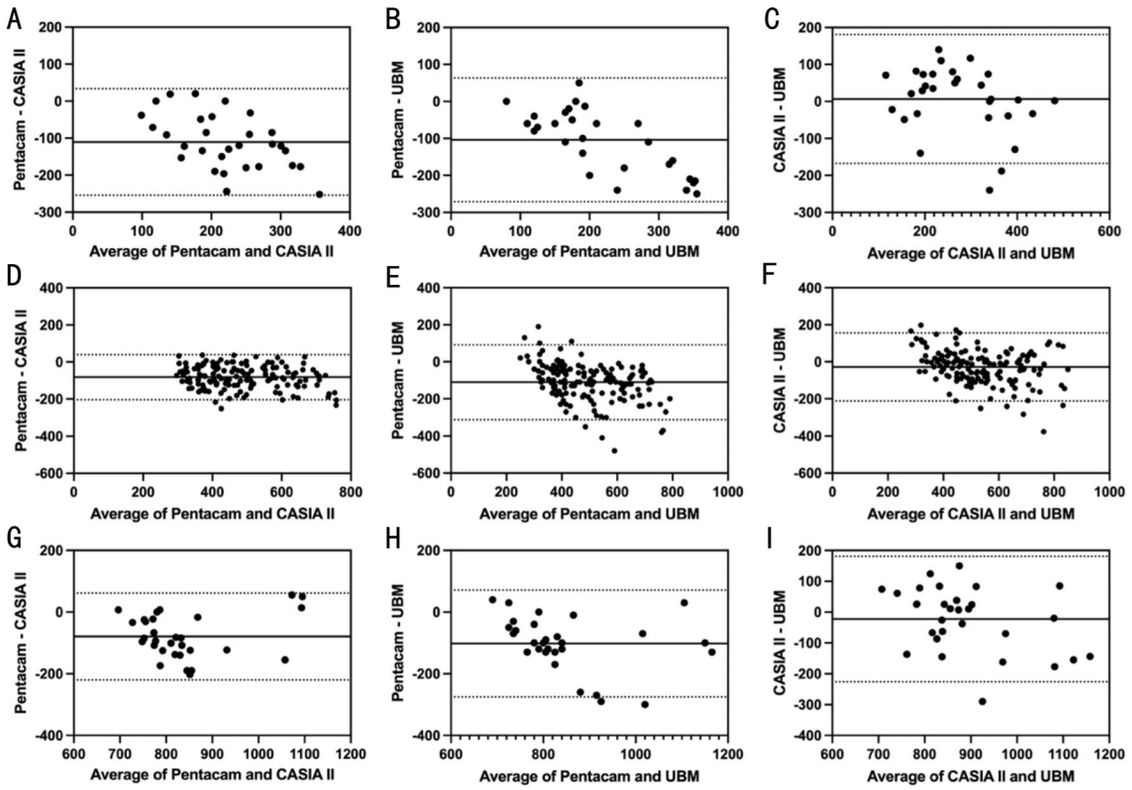

Figure 3 Bland and Altman plots compare the level of agreement between the three instruments for vault measurements in low vault (vault ≤ 250 μm, A, B, C), medium vault (250<vault<700 μm, D, E, F) and high vault (vault ≥700 μm, G, H, I) The vertical axis represents the difference between these measurements, and the horizontal axis shows their mean value. Dashed lines represent the 95% limits of agreement. Solid line represents the mean difference. All scales are in μm.

ICL central contact on Scheimpflug tomography, AS-OCT can still measure the vault, even if it is low. Therefore, we divided the eyes into three groups based on the Pentacam-measured vault values and compared the differences and consistency of different instruments at different vault levels. The results showed that the correlation between Pentacam and CASIA II and Pentacam and UBM were significantly lower in the low-vault group than in the medium- and high-vault groups and the ICC values were also significantly low. The mean vault difference between Pentacam and CASIA II was -110.47±73.38 μm in the low vault group and -82.31±62.18 and -79.47±71.80 μm in the medium and high vault groups, respectively. Between Pentacam and CASIA II, 95% LOA of vault measurements was -254.30 to 33.37 μm in the low vault group, -204.18 to 39.55 μm and -220.19 to 61.26 μm in the medium and high vault groups, respectively. The mean difference and 95% LOA in the low-vault group were more than those in the medium- and high-vault groups and the consistency of the Pentacam and CASIA II measurements in the low-vault group was reduced, indicating that the low vault affected the measurement of Pentacam. In the low-vault group, the consistency between CASIA II and UBM was better than that between Pentacam and their combinations. This may be because, at low vaults, CASIA II and UBM have the advantages of high resolution and measurement accuracy, whereas the Pentacam images have unclear boundaries and higher measurement errors.

Regarding the gold standard for vault measurements, Wan *et al*[18] believed it impossible to determine the most accurate method. However, Almorín-Fernández-Vigo *et al*[14] reported that AS-OCT has a higher resolution and better reproducibility for vault measurements than Scheimpflug tomography and UBM. Accordingly, AS-OCT should be considered the gold standard technique for vault measurement. For economic reasons, Pentacam can be used for routine follow-up with postoperative vaults, and CASIA II is recommended for patients with low vaults. CASIA II has a higher resolution than the Pentacam and is more accurate in measuring low vaults. Although UBM also has a high resolution, it is more complex to operate, has a greater error, requires contact with the patient's eyeball, takes a longer examination time, and is unsafe to perform in the early postoperative period. In contrast, CASIA II does not touch the patient's eyeball, making the examination quick and easy and rendering the patient more acceptable.

For patients with extreme vault sizes, UBM may be performed, if necessary, to obtain more detailed information on the position of the ICL haptics. UBM can be used to observe

the morphology of the ciliary sulcus and the location of lens haptics, which is helpful for some patients with extreme vault to find the cause and provide further treatment. In addition, due to the inverted curvature design of the surrounding area where the ICL haptics are located, the possibility of peripheral contact between the ICL and the lens is increased[31], performing UBM or CASIA II after pupil dilation helps visualize the relative position of the ICL periphery and the lens. When analyzing the vault, it should be noted as a dynamically changing parameter, and the safety is evaluated based on the patient's specific situation rather than strictly following the numerical standard of 250-750 μm.

A limitation of this study is that the pupil size corresponding to different instruments was not measured, and the reasons for the difference in the vault were not specifically analyzed. Then, the number of participants measured in this study was relatively small, especially in the low- and high-vault groups.

The vault values measured by the Pentacam were lower than those measured by CASIA II and UBM, with UBM showing the highest average vault value. Vault values measured by the three instruments were not interchangeable, but could be used as references. Vault values measured using the three instruments were significantly correlated and showed good agreement, with the Pentacam *vs* CASIA II being preferred. When the vault ≤250 μm, Pentacam is limited by resolution and has a large measurement error. The differences among the three devices should be recognized, especially in patients with a low vault in clinical practice.

ACKNOWLEDGEMENTS

We would like to thank Editage (www.editage.cn) for English language editing.

Foundations: Supported by the National Natural Science Foundation of China (No.82171095); the Project of Shanghai Science and Technology (No.23XD1400500); the Research Fund of Sichuan Academy of Medical Sciences and Sichuan Provincial People's Hospital (No.24QNPY049).

Conflicts of Interest: Li BL, None; **Cheng MR,** None; **Chang WT,** None; **Lei YD,** None; **Xu GH,** None; **Li MW,** None; **Mao ZW,** None; **Chen X,** None; **Wang XY,** None.

REFERENCES

1 Martínez-Plaza E, López-de la Rosa A, López-Miguel A, *et al*. EVO/EVO+ Visian Implantable Collamer Lenses for the correction of myopia and myopia with astigmatism. *Expert Rev Med Devices* 2023;20(2):75-83.

2 Montés-Micó R, Ruiz-Mesa R, Rodríguez-Prats JL, *et al*. Posterior-chamber phakic implantable collamer lenses with a central port: a review. *Acta Ophthalmol* 2021;99(3).

3 Chung B, Choi JY, Kang DSY, *et al*. Ten-year clinical outcomes of V4c implantable collamer lens implantation: longitudinal analysis of visual acuity, endothelial cell density, and vault dynamics. *Am J Ophthalmol* 2025;269:1-10.

4 Yuan J, Wu S, Hu ZL, *et al*. Clinical observation of posterior-chamber phakic implantable collamer lens V4c implantation in myopic patients with shallow anterior chamber depth: a retrospective, consecutive observational study. *J Ophthalmol* 2024;2024:3181569.

5 Lin IC, Jiang YJ, Cheng MR, *et al*. Long-term evaluation of central and peripheral lens densities post implantation of implantable collamer lens V4c. *Clin Ophthalmol* 2025;19:733-745.

6 Wu WM, Liu JW, Zhang L, *et al*. Development and validation of a novel vault prediction formula based on structural parameters of the anterior and posterior chambers. *BMC Ophthalmol* 2024;24(1):349.

7 Wang Q, Chen X, Li L, *et al*. Effect of anterior segment structure on vault and position after implantable collamer lens implantation. *Indian J Ophthalmol* 2024;72(9):1298-1303.

8 Xu YJ, Liu F, Ye YH, *et al*. Establishment of a new vault prediction formula after implantable collamer lens implantation based on factor analysis of multi-modal ophthalmic parameters of anterior and posterior chamber. *Clin Exp Ophthalmol* 2024;52(9):920-933.

9 Wei RY, Li MY, Aruma A, *et al*. Factors leading to realignment or exchange after implantable collamer lens implantation in 10258 eyes. *J Cataract Refract Surg* 2022;48(10):1190-1196.

10 Zeng QY, Xie XL, Chen Q. Prevention and management of collagen copolymer phakic intraocular lens exchange: causes and surgical techniques. *J Cataract Refract Surg* 2015;41(3):576-584.

11 Gonzalez-Lopez F, Mompean B, Bilbao-Calabuig R, *et al*. Dynamic assessment of light-induced vaulting changes of implantable collamer lens with central port by swept-source OCT: pilot study. *Transl Vis Sci Technol* 2018;7(3):4.

12 Kato S, Shimizu K, Igarashi A. Vault changes caused by light-induced pupil constriction and accommodation in eyes with an implantable collamer lens. *Cornea* 2019;38(2):217-220.

13 Song ZH, Li Q, Xiong Y, *et al*. Effect of lighting conditions on implantable collamer lens vault: Influence of anterior chamber and lens parameters. *Heliyon* 2024;10(18):e37895.

14 Almorín-Fernández-Vigo I, Sánchez-Guillén I, Fernández-Vigo JI, *et al*. Agreement between optical coherence and Scheimpflug tomography: Vault measurements and reproducibility after implantable collamer lens implantation. *J Fr Ophtalmol* 2021;44(9):1370-1380.

15 Wu H, Wang ZC, Wang PF, *et al*. Repeatability and agreement of central vault for implantable collamer lens obtained by the tomey OA-2000 biometer and spectralis OCT. *J Ophthalmol* 2024;2024: 3684626.

16 Li BL, Chen X, Cheng MR, *et al*. Long-term vault changes in different levels and factors affecting vault change after implantation of implantable collamer lens with a central hole. *Ophthalmol Ther* 2023;12(1):251-261.

17 Jiang YJ, Shen Y, Wang L, *et al*. Effect of vault on predicting postoperative refractive error for posterior chamber phakic intraocular lens based on a machine learning model. *J Cataract Refract Surg* 2024;50(4):319-327.

18 Wan T, Yin HF, Yang Y, *et al*. Comparative study of anterior segment measurements using 3 different instruments in myopic patients after ICL implantation. *BMC Ophthalmol* 2019;19(1):182.

19 Wei RY, Cheng MR, Niu LL, *et al*. Outcomes of the EVO ICL using a customized non-horizontal or horizontal implanting orientation based on UBM measurement: a pilot study. *Ophthalmol Ther* 2022;11(3):1187-1198.

20 Wei RY, Li MY, Zhang HH, *et al*. Comparison of objective and subjective visual quality early after implantable collamer lens V4c (ICL V4c) and small incision lenticule extraction (SMILE) for high myopia correction. *Acta Ophthalmol* 2020;98(8).

21 Lei CS, Lin XQ, Ning R, *et al*. Repeatability and interobserver reproducibility of a swept-source optical coherence tomography for measurements of anterior, posterior, and total corneal power. *Ophthalmol Ther* 2023;12(6):3263-3279.

22 Saito A, Kamiya K, Fujimura F, *et al*. Comparison of angle-to-angle distance using three devices in normal eyes. *Eye* (*Lond*) 2020;34(6):1116-1120.

23 Zhang T, Zhou YJ, Young CA, *et al*. Comparison of a new swept-source anterior segment optical coherence tomography and a scheimpflug camera for measurement of corneal curvature. *Cornea* 2020;39(7):818-822.

24 Huang XM, Lin XQ, Yang YZ, *et al*. Comparison of a new scheimpflug camera and swept-source optical coherence tomographer for measurements of anterior segment parameters. *Ophthalmol Ther* 2023;12(6):3187-3198.

25 Fukuda S, Ueno Y, Fujita A, *et al*. Comparison of anterior segment and lens biometric measurements in patients with cataract. *Graefes Arch Clin Exp Ophthalmol* 2020;258(1):137-146.

26 Xu BY, Mai DD, Penteado RC, *et al*. Reproducibility and agreement of anterior segment parameter measurements obtained using the CASIA2 and spectralis OCT2 optical coherence tomography devices. *J Glaucoma* 2017;26(11):974-979.

27 Zhao J, Zhao J, Yang W, *et al*. Consecutive contralateral comparison of toric and non-toric implantable collamer lenses V4c in vault after implantation for myopia and astigmatism. *Acta Ophthalmol* 2021;99(6).

28 Li F, Ma YN, Qi WJ, *et al*. Characteristics of biological parameters and implantable collamer lens (ICL) size selection in moderate, high, and super-high myopia eyes. *BMC Ophthalmol* 2025;25(1):103.

29 Shimada R, Katagiri S, Horiguchi H, *et al*. Prediction of vaults in eyes with vertical implantable collamer lens implantation. *J Cataract Refract Surg* 2025;51(1):45-52.

30 Yamashita K, Kobayashi M, Igarashi A, *et al*. Enhanced ICL sizing accuracy using advanced optical coherence tomography-based predictive formula. *Am J Ophthalmol* 2024;268:86-93.

31 Guber I, Mouvet V, Bergin C, *et al*. Clinical outcomes and cataract formation rates in eyes 10 years after posterior phakic lens implantation for myopia. *JAMA Ophthalmol* 2016;134(5):487-494.