Anterior Segment Characteristics Changes after Implantable Collamer Lens V4c in Low Anterior Chamber Depth Eyes: An Optical Coherence Tomography Study

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ABSTRACT

PURPOSE: To investigate anterior segment changes after implantable collamer lens V4c (ICL-V4c; STAAR Surgical) implantation in eyes with low anterior chamber depth (ACD) and compare them with eyes with normal ACD.

METHODS: This prospective, interventional case-control study included 96 eyes of 48 patients with a low ACD (< 2.8 mm) and 44 eyes of 22 patients with normal ACD (≥ 2.8 mm) receiving a 12.1-mm ICL. All patients underwent follow-up and comprehensive ophthalmic examinations preoperatively and at 1, 3, and 6 months after surgery. Anterior segment parameters, including ACD, anterior chamber width, crystalline lens rise, anterior chamber angle, trabecular-iris angle (TIA), angle opening distance, trabecular-iris space area, the distance from cornea to ICL, and vault were all conducted by optical coherence tomography. These parameters from the last follow-up (6 months postoperatively) were used for statistical analysis to assess changes in anterior segment structure and their relationship with vault height.

RESULTS: The mean safety and efficacy index in eyes with low ACD were 1.23 ± 0.22 and 1.21 ± 0.08 respectively. In both groups, anterior chamber structure parameters become narrower compared to preoperatively (all $P < .05$). Preoperative ACD and C-ICL demonstrated significant correlations with ICL vault in eyes with low ACD ($P < .001$). Compared with eyes with normal ACD preoperatively, eyes with low ACD are more prone to have low vault ($P < .01$). There is a correlation between normal vault and corneal horizontal white-to-white distance ($P = .032$), ACD ($P = .046$), and temporal TIA_{500} ($P = .016$).

CONCLUSIONS: ICL-V4c surgery in eyes with low ACD is safe and efficacious. In patients with low ACD, the normal vault could be better anticipated by considering preoperative anterior chamber angle, white-to-white distance, and ACD.

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The implantable collamer lens (ICL), a posterior chamber phakic intraocular lens, has found widespread application in refractive surgery.[1,2] Following surgery, due to the lens implantation, the anterior segment of the eye becomes crowded. Anatomical features like narrow angles and inappropriate vault may be linked to postoperative complications such as anterior subcapsular cataracts (ASC) and secondary glaucoma.[3,4] Currently, various online ICL calculation formulas only offer recommendations for artificial lens size and crude predictions for postoperative vault in patients with anterior chamber depth

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(ACD) greater than 2.8 mm.[5,6] However, there is a lack of clinical data for patients with low ACD (< 2.8 mm), because the manufacturer does not recommend ICL implantation in patients with an ACD of less than 2.8 mm. Nevertheless, such patients are not uncommon among Asian populations.[7] In addition, studies suggested that due to the anatomical characteristics of patients with low ACD, marked by a lower ACD and smaller white-to-white (WTW) measurements, postoperative ASC has been reported in some patients.[8,9] However, these studies were primarily focused on the older ICL model. In recent years, the unique design of the ICL-V4c model (STAAR Surgical), featuring a 360-μm central hole has facilitated aqueous flow and thus achieved a better preservation of the normal physiological structure of the anterior segment.[10,11] Its long-term safety and efficacy after implantation have been validated through clinical follow-ups.[12-14] Understanding the anterior chamber features in patients with low ACD undergoing ICL-V4c surgery is of great importance in establishing surgical indications, predicting postoperative anterior segment structures, and earlier and more sensitive detection of postoperative complications.[15-17]

Optical coherence tomography (OCT) rapidly images ocular structures in a non-contact manner, yielding higher resolution images that facilitate the visualization of intricate anatomical details.[18] As a result, it has been increasingly used to measure anterior segment structures, map corneal layers, assess angles, and conduct high-resolution cross-sectional imaging.[19,20]

To identify the structural changes in the anterior segment in patients with low ACD undergoing ICL-V4c surgery, we evaluated the safety and efficacy of this procedure. We used OCT to observe changes in anterior segment parameters in healthy myopic patients. Using these measurements, we evaluated the correlation of these parameters preoperatively with vault, to establish the predictive value of these preoperative parameters for forecasting postoperative ICL vault.

PATIENTS AND METHODS

PARTICIPANTS

This study prospectively enrolled myopic patients who had undergone ICL-V4c surgery at Xi'an Aier Eye Hospital between October 2022 and October 2023. The study adhered to the principles of the Declaration of Helsinki and received approval from the ethics committee of Xi'an Aier Eye Hospital (ChiCTR2300077684). All participants were informed about the content and voluntarily signed the consent form.

This study included a total of 140 eyes of 70 participants. Participants were categorized into two groups based on the preoperative ACD measured from OCT images: low ACD (< 2.8 mm) and normal ACD (≥ 2.8 mm). Each participant underwent a comprehensive ophthalmic examination preoperatively and at 1, 3, and 6 months after surgery, which included logarithm of the minimum angle of resolution (logMAR) uncorrected distance visual acuity (UDVA), logMAR corrected distance visual acuity (CDVA), refractive error, slit-lamp microscopy, funduscopy, central corneal thickness (CCT) (Pachymeter SP-3000; Tomey Corporation), WTW horizontal corneal diameter (Oculus Pentacam AXL 70100; Oculus Optikgeräte GmbH), endothelial cell count (ECD) (SP-3000P; Topcon Corporation), non-contact tonometry for intraocular pressure (IOP) (NT-510, NIDEK Co, Ltd), and OCT examination of the anterior segment (CIRRUS HD-OCT 5000; Carl Zeiss Meditec AG).

The inclusion criteria for the study included healthy myopic individuals aged between 19 and 45 years, with a stable refractive status for at least 2 years before surgery. Participants who wore soft contact lenses discontinued their use for at least 1 week, whereas those using rigid gas permeable lenses and orthokeratology lenses ceased their use for 1 and 3 months, respectively. Additionally, participants were required to have a corneal ECD of 2,000/mm² or greater. Exclusion criteria included a history of corneal surgery and concurrent ocular conditions such as infectious keratitis, keratoconus, glaucoma, and cataracts. Other exclusion criteria included systemic conditions such as hypertension, diabetes, or any systemic diseases leading to immunodeficiency. Those who were pregnant or lactating were also excluded from the study.

OPTICAL COHERENCE TOMOGRAPHY

These patients underwent OCT examinations conducted by trained physicians during the initial consultation and postoperative follow-up. Using a T10A illuminance meter (Konica Minolta), light intensity was recorded to ensure that OCT measurements for all patients were performed under consistent illumination conditions. This was implemented to mitigate potential changes in myosis and mydriasis that might influence variables such as vault. The patients were seated, and scans were performed with the central pupil as the focal point. The examination involved temporal-to-nasal scanning for the right eye and nasal-to-temporal scanning for the left eye. Scans are needed to ensure clear boundaries and optimal visualization of the scleral spur, corneal endothelium, iris pigment epithelium, anterior lens capsule, and the anterior and posterior surfaces of the artificial lens. The selected images were stored in the equipment (**Figure A**).

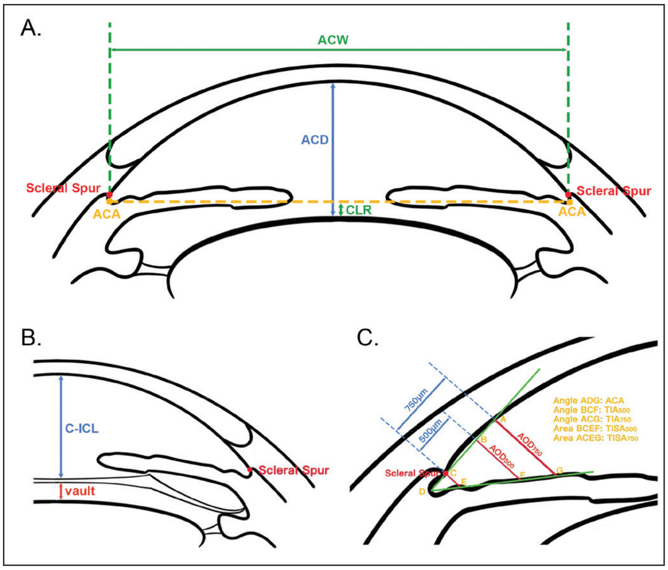

Figure 1. Optical coherence tomography and ImageJ measurement parameters of the anterior segment. (A) Anterior chamber depth (ACD), anterior chamber width (ACW), crystalline lens rise (CLR). (B) Distance from cornea to implantable collamer lens (C-ICL), vault. (C) Anterior chamber angle (ACA), TIA_{500}, TIA_{750}, AOD_{500}, AOD_{750}, $TISA_{500}$, $TISA_{750}$. AOD = angle opening depth; TIA = trabecular-iris angle; TISA = trabecular-iris space area

Measurement of Anterior Segment Structural Parameters

An experienced clinical physician selected the best OCT images based on clinical information. By manipulating image contrast in Photoshop 22.4.2 (Adobe), we aimed to aid physicians in identifying the cornea, ICL, lens surfaces, and scleral spur more effectively. Further enhancement involved marking distances of 500 and 750 µm from the scleral spur using rulers, straight lines, and rectangular tools. Subsequently, the preoperative and the last visit OCT parameters were quantitatively assessed using ImageJ version 1.53a (National Institutes of Health). All parameters were measured twice, and the average value of the two measurements was used subsequent statistical analysis. The definitions of these quantitative parameters (**Figure 1**) are:

1. ACD measurement is the distance from the corneal endothelium to the anterior surface of the crystalline lens centered over the pupil.[21]
2. Vault is the distance between the central posterior surface of the ICL and the anterior surface of the crystalline lens.[22]
3. C-ICL measurement is the distance from the corneal endothelium to the anterior surface of the ICL, centered on the pupil.[22]
4. Anterior chamber width (ACW) is defined as the distance between the scleral spurs on the nasal and temporal sides in horizontal OCT scans.[23]
5. The crystalline lens rise (CLR) is defined as the distance between the angle to angle (ATA) line and the crystalline lens anterior surface (positive values if anterior, negative values if posterior to the ATA line).[24]
6. Anterior chamber angle (ACA) is the angle between the inner surface of the cornea and the anterior surface of the iris.[22]
7. Trabecular-iris angles 500 and 750 (TIA_{500} and TIA_{750}) are measured with the scleral spur as the apex, and the arms of the angle passing through a point on the inner corneal surface at a distance of 500 or 750 µm from the scleral spur, and a point on the anterior surface of the iris perpendicular to it.[21,25]
8. Angle opening distances 500 and 750 (AOD_{500} and AOD_{750}) are the perpendicular distance from a point located 500 or 750 µm from the scleral spur to the anterior surfaces of the iris along the inner corneal surface.[25,26]
9. Trabecular-iris space areas 500 and 750 ($TISA_{500}$ and $TISA_{750}$) are the trapezoidal areas enclosed by AOD_{500} or AOD_{750}, the anterior surface of the iris, the inner corneal surface, and a vertical line extending from the scleral spur to the anterior surface of the iris.[25,26]

Surgical Procedure

The selection of the ICL size, based on ACD and WTW, was calculated by the manufacturer through an online calculator (https://evo-ocos.staarag.ch; version 4.08). In this study, all patients with low ACD were advised to receive the 12.1-mm ICL model due to their anatomical characteristics. To control for confounding factors between the two groups, this study only included subjects using the 12.1-mm size of the ICL-V4c model (STAAR Surgical), and all procedures were performed by the same experienced surgeon. The main incision was made along the steepest meridian of the cornea. After the topical administration of a mydriatic agent and surface anesthesia, a ICL-V4c or a V4c toric ICL (TICL) was inserted through a 2.8-mm clear corneal incision. Postoperatively, patients were prescribed topical nonsteroidal anti-inflammatory drugs (Pranoprofen; Pranopulin) and antibiotics (Levofloxacin, Cravit; Santen) four times a day for a consecutive 2-week period, with a gradual reduction thereafter.

Statistical Analyses

Statistical analysis of all data in this study was conducted using SPSS version 26 (IBM Corporation) and GraphPad Prism version 9.5.0 (GraphPad, Inc) software. Continuous variables were presented as mean ±

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TABLE 1

Demographics and Preoperative Basic Clinical Data of Recruited Eyes

Parameter	Mean ± SD (Range) Low ACD (< 2.8 mm, n = 96)	Normal ACD (≥ 2.8 mm, n = 44)	P
Gender (female/male), n	84/12	42/2	
Age (y)	30.92 ± 5.69 (20 to 45)	30.68 ± 7.20 (19 to 46)	.836
CCT (μm)	527.88 ± 34.84 (458 to 600)	513.40 ± 33.87 (452 to 579)	.026[a]
WTW (mm)	11.14 ± 0.32 (10.4 to 11.9)	11.17 ± 0.45 (10.5 to 12.4)	.667
Pupil size (mm)	2.97 ± 0.69 (1.92 to 6.87)	3.25 ± 0.74 (1.97 to 6.21)	.539
ECD (cells/mm^2)	2691.99 ± 308.29 (2035 to 3354)	2775.55 ± 596.37 (2100 to 6172)	.287
IOP (mm Hg)	13.57 ± 2.55 (8.0 to 18.0)	13.88 ± 2.12 (9.0 to 18.3)	.493
ACD (mm)	2.62 ± 0.10 (2.37 to 2.79)	2.97 ± 0.13 (2.81 to 3.32)	< .001[a]
Spherical (D)	-8.10 ± 2.34 (-15.50 to -3.25)	-7.57 ± 2.71 (-15.50 to -2.25)	.248
Cylinder (D)	-0.89 ± 0.75 (-3.75 to 0.00)	-0.99 ± 0.81 (-3.50 to 0.00)	.453
SE (D)	-8.47 ± 2.58 (-16.00 to -1.50)	-8.03 ± 2.65 (-16.00 to -3.75)	.362
UDVA (logMAR)	0.08 ± 0.06 (0.02 to 0.4)	0.08 ± 0.06 (0.02 to 0.3)	.461
CDVA (logMAR)	0.92 ± 0.11 (0.6 to 1.0)	0.90 ± 0.15 (0.5 to 1.0)	.426

ACD = anterior chamber depth; CCT = central corneal thickness; CDVA = corrected distance visual acuity; D = diopters; ECD = endothelial cell density; IOP = intraocular pressure; logMAR = logarithm of the minimum angle of resolution; SD = standard deviation; UDVA = uncorrected distance visual acuity; WTW = white-to-white distance
[a]*P < .05 is considered significant.*

standard deviation. We used the Kolmogorov-Smirnov test and histograms to assess the normality of continuous data. The consistency between measurements was assessed using the Bland-Altman analysis. Consistency limits were defined as the difference between the means of two measurements ±1.96 times the standard deviation of the difference. The Student's *t*-test was used for normally distributed data, and the Wilcoxon signed-rank test for non-normally distributed data. Univariate and multivariate linear regression analyses were performed to pinpoint preoperative and the last visit (6 months after surgery) anterior chamber structural parameters significantly correlated with the vault. Parameters with a *P* value less than .05 in the univariate analysis were included in the multivariate models. A *P* value less than .05 was considered statistically significant.

RESULTS

A total of 140 eyes of 70 individuals (14 men and 126 women) were included. The average age of participants was 30.84 ± 6.18 years. The ACD, measured by OCT, ranged from 2.37 to 3.32 mm (2.727 ± 0.195 mm). **Table 1** compares the preoperative data between the two groups. As expected, measurements of ACD using OCT revealed statistically significantly greater in the normal ACD group compared to the low ACD group (*P* < .001 for all). Bland-Altman plots showed no systematic difference in consistency between OCT measurements (**Figure B**).

No postoperative complications were observed during the follow-up period. **Figures 2-3** illustrate the refractive alterations following ICL-V4c surgery in the low ACD group and the normal ACD group, respectively. At the final follow-up, the mean safety indices (postoperative CDVA / preoperative CDVA) for both groups were 1.23 ± 0.22 and 1.17 ± 0.35, respectively, whereas the mean efficacy indices (postoperative UDVA / preoperative CDVA) were 1.21 ± 0.08 and 1.23 ± 0.18, respectively. For the low ACD group, 84 eyes (87.5%) showed a final spherical equivalent within ±0.50 D of the target, and 94 eyes (97.9%) within ±1.00 D. In the normal ACD group, 38 eyes (86.4%) attained a postoperative spherical equivalent within ±0.50 D, with 44 eyes (100%) achieving this within ±1.00 D.

Table 2 delineates preoperative and postoperative comparisons of diverse anterior chamber parameters measured by OCT in both groups of patients after ICL-V4c surgery. Compared to preoperative measurement, as expected, both groups demonstrated a decrease in ACD after surgery (the low ACD group: *P* < .001, the normal ACD group: *P* = .002). Moreover, compared to preoperative, both groups demonstrated decreased ACW and related chamber angle parameters on the nasal and temporal sides after surgery (*P* < .001 for all).

Given its clinical significance (impact on postoperative aqueous flow and the chance of endothelial cell loss and cataract formation), we chose the ICL vault as the key variable in the different regression analyses to

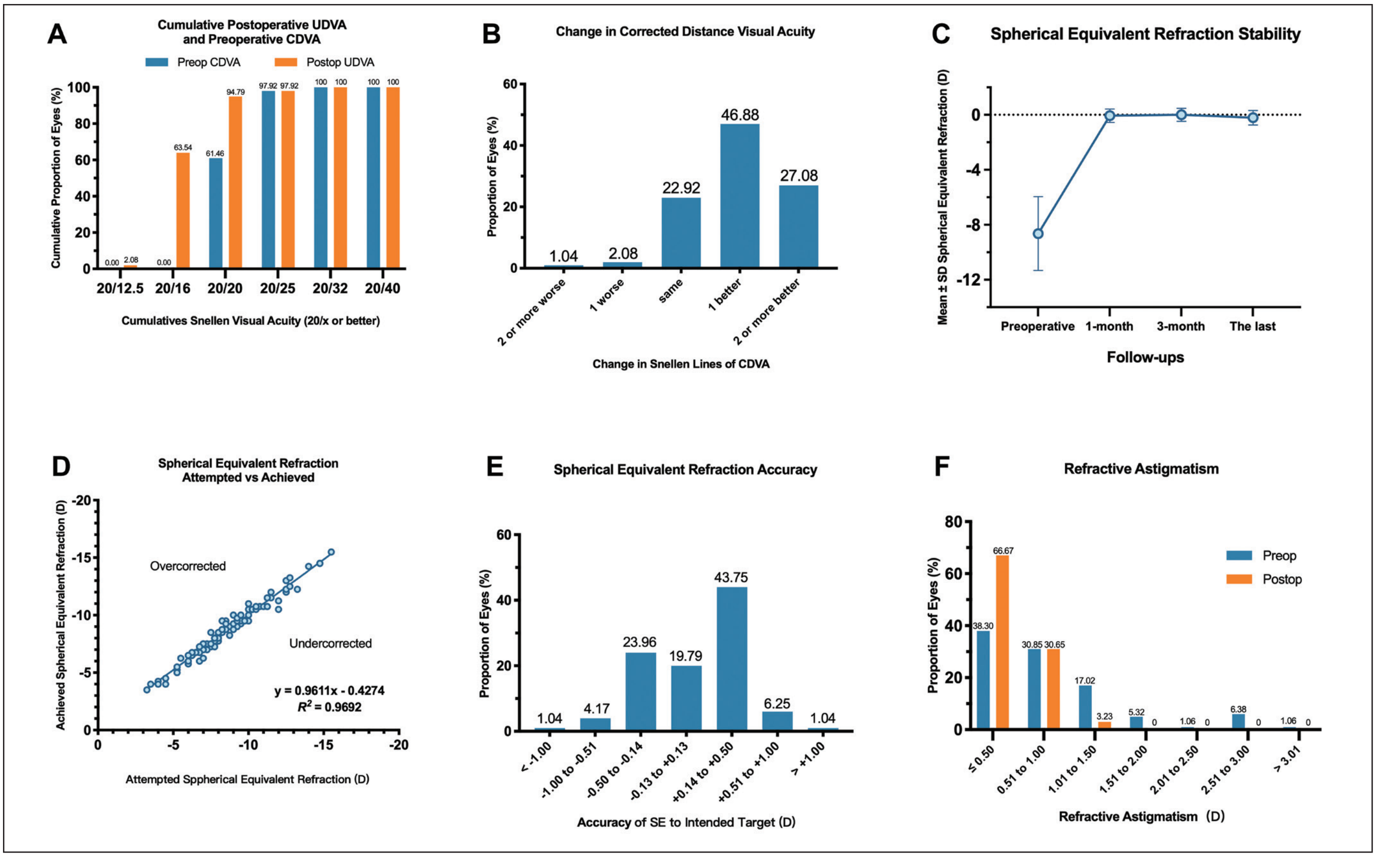

Figure 2. Standardized graphs for presenting refractive outcomes of ICL-V4c (STAAR Surgical) implantation in eyes with low anterior chamber depth (ACD) (n = 96) at 6 months. (A) Efficacy, specifically, uncorrected distance visual acuity (UDVA). (B) Safety, depicting the change in corrected distance visual acuity (CDVA). (C) Stability, showing the change in spherical equivalent (SE) refraction over time. (D) Predictability, comparing attempted versus achieved SE. (E) Accuracy of SE refraction, outlining refractive SE outcomes. (F) Astigmatism, displaying postoperative residual astigmatism on refraction. D = diopters

examine the correlation between the ICL vault and various preoperative anterior chamber parameters and we conducted a regression analysis on vault and postoperative 6-month parameters (**Table 3** and **Table A**). In **Table 3**, the postoperative ICL vault in the low ACD group shows a significant correlation with preoperative ACD ($\beta = 0.267$; $P < .001$). In the normal ACD group, the ICL vault demonstrated a significant correlation with postoperative ACD ($\beta = 0.569$; $P < .001$) and C-ICL ($\beta = -0.959$; $P < .001$) (**Table A** and **Figure 4**).

Patients in both groups who exhibited low postoperative vault are listed in **Table 4**. The chi-square test revealed a significant difference between the two groups ($P < .001$) (**Table B**). The low ACD group had a higher risk of low vault compared to the normal ACD group (38.54% vs 11.36%; odds ratio = 4.89; 95% confidence interval = 1.86 to 12.21). In the low ACD group, we performed additional regression analysis to study the correlation of low vault versus normal vault with various anterior segment parameters (**Table 5**). Some parameters related to the anterior chamber angle are significantly correlated with vault. Among patients with low ACD, individuals with a smaller WTW and a greater preoperative ACD are more likely to show a normal vault (with P values of .032 and .046, respectively). Therefore, we selected these parameters to predict the normal ICL vault in patients with low ACD for diagnostic testing. **Figure 5** shows the receiver operating characteristic curves for these parameters among the patients with low ACD for the identification of postoperative normal vault. The areas under the curve of parameters for normal vault in patients with low ACD are shown in **Table 6**. WTW ($P = .007$) and ACD ($P = .046$) demonstrated great diagnostic performance, with areas under the curve ranging from 0.548 to 0.784 and 0.505 to 0.738, respectively.

DISCUSSION

ICL vault is a crucial indicator for evaluating the safety of ICL procedures postoperatively. Excessive vault values may precipitate endothelial cell loss, whereas insufficient vault height is a major cause of postoperative ASC.[3,27,28] In the current study, patients with low ACD demonstrated remarkable safety and ef-

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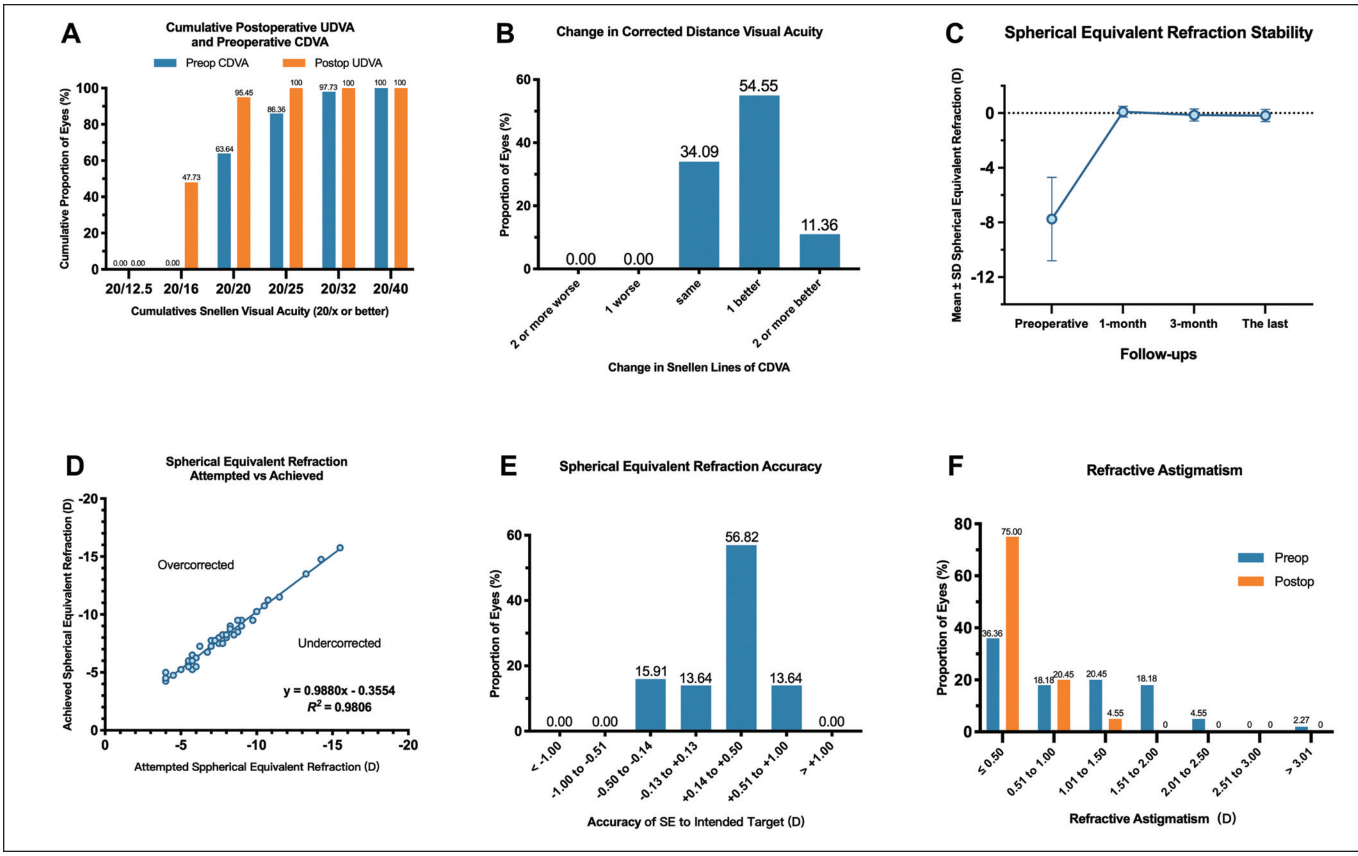

Figure 3. Standardized graphs for presenting refractive outcomes of ICL-V4c (STAAR Surgical) implantation in eyes with normal anterior chamber depth (ACD) (n = 44) at 6 months. (A) Efficacy, specifically, uncorrected distance visual acuity (UDVA). (B) Safety, depicting the change in corrected distance visual acuity (CDVA). (C) Stability, showing the change in spherical equivalent (SE) refraction over time. (D) Predictability, comparing attempted versus achieved SE. (E) Accuracy of SE refraction, outlining refractive SE outcomes. (F) Astigmatism, displaying postoperative residual astigmatism on refraction. D = diopters

ficacy after undergoing ICL-V4c surgery. No adverse reactions such as secondary glaucoma, cataracts, or endothelial cell loss have been observed postoperatively.[9,15,16] Although many studies confirmed that postoperative vault in patients with low ACD are lower than those in patients with normal ACD,[16,29] to date, little is known about the quantitative comparisons between these two groups, including the safety and efficacy of surgery, association between ICL vault and various anterior chamber structural parameters. To this end, we have designed and conducted this study.

There are numerous studies indicating a correlation between ACD and ICL size selection, as well as postoperative vault.[30,31] Subsequently, substantial clinical data supported the evaluation of postoperative safety based on preoperative parameters in patients with normal ACD. However, due to the design of the traditional ICL model without a central hole and the recommendation from the lens manufacturer, ICL surgery is not advised for patients with low ACD. Therefore, there is limited research on ICL-V4c surgery in these patients. For patients with low ACD, Qian et al[16] reported on patients with relatively low ACD (2.47 to 2.79 mm) who underwent ICL-V4c surgery, with a mean safety index of 1.10 ± 0.16 and a mean efficacy index of 1.04 ± 0.15 after 1-year follow-up. This corresponds well with the result of our study. Moreover, our study, which focused on patients with low ACD, incorporated a control group of patients with normal ACD for comparison. The mean postoperative safety indices for the two groups were 1.23 ± 0.22 and 1.17 ± 0.35, and the mean efficacy indices were 1.21 ± 0.08 and 1.23 ± 0.18, respectively. We further noted that, in these eyes with low ACD, 87.5% and 97.9% of eyes were within ±0.50 and ±1.00 D of the attempted SE, indicating a high degree of predictability with ICL-V4c surgery for eyes with low ACD.

The mean ECD for patients with low ACD was 2,691.99 ± 308.29 cells/mm² preoperatively and 2,638.96 ± 304.23 cells/mm² at the final follow-up. In the normal ACD group, the mean ECD were 2,775.55 ± 496.37 cells/mm² preoperatively and 2,717.54 ± 488.76 cells/mm² at the final follow-up. Compared to preoperative values, ECD decreased by 1.97 ± 2.64%

TABLE 2

Comparison of Anterior Segment Parameters Measurements of Recruited Eyes Between Low ACD and Normal ACD

	Low ACD (< 2.8 mm, n = 96), Mean ± SD (Range)			Normal ACD (≥ 2.8 mm, n = 44), Mean ± SD (Range)				
Parameter	**Preop**	**Postop**	***P***	**Preop**	**Postop**	***P***	***P*[a]**	***P*[b]**
ACD (μm)	2617.80 ± 100.94	2576.72 ± 103.42	< .001[c]	2964.46 ± 126.94	2921.58 ± 143.56	.002[c]	< .001[c]	< .001[c]
ACW (μm)	11254.89 ± 361.59	11099.65 ± 403.12	< .001[c]	11322.80 ± 398.37	11126.08 ± 428.59	< .001[c]	.320	.725
CLR (μm)	34.71 ± 211.34	32.74 ± 211.91	.979	-322.66 ± 187.15	-302.94 ± 198.88	.633	< .001[c]	< .001[c]
Temporal								
ACA (°)	37.90 ± 4.86	22.97 ± 4.28	< .001[c]	40.52 ± 5.83	25.40 ± 3.61	< .001[c]	.006[c]	< .001[c]
TIA_{500} (°)	45.04 ± 6.16	32.55 ± 6.17	< .001[c]	51.72 ± 7.20	38.55 ± 5.99	< .001[c]	< .001[c]	< .001[c]
TIA_{750} (°)	42.74 ± 6.20	28.77 ± 4.88	< .001[c]	48.84 ± 6.32	34.31 ± 4.71	< .001[c]	< .001[c]	< .001[c]
AOD_{500} (μm)	516.83 ± 114.56	326.83 ± 77.28	< .001[c]	661.76 ± 185.15	407.36 ± 83.10	< .001[c]	< .001[c]	< .001[c]
AOD_{750} (μm)	712.87 ± 160.93	419.73 ± 84.95	< .001[c]	890.79 ± 215.04	522.19 ± 87.47	< .001[c]	< .001[c]	< .001[c]
$TISA_{500}$ (μm²)	183396.48 ± 38972.47	123853.26 ± 31217.32	< .001[c]	245120.25 ± 70818.95	156656.61 ± 36130.67	< .001[c]	< .001[c]	< .001[c]
$TISA_{750}$ (μm²)	348863.95 ± 72037.50	220494.29 ± 46003.76	< .001[c]	451678.84 ± 111852.55	277616.34 ± 52507.65	< .001[c]	< .001[c]	< .001[c]
Nasal								
ACA (°)	34.10 ± 4.07	20.05 ± 3.84	< .001[c]	37.34 ± 4.15	21.96 ± 4.00	< .001[c]	< .001[c]	< .001[c]
TIA_{500} (°)	42.95 ± 6.52	30.39 ± 6.59	< .001[c]	51.37 ± 5.93	35.78 ± 5.69	< .001[c]	< .001[c]	< .001[c]
TIA_{750} (°)	40.39 ± 5.73	26.29 ± 5.45	< .001[c]	47.62 ± 5.41	31.41 ± 4.25	< .001[c]	< .001[c]	< .001[c]
AOD_{500} (μm)	479.98 ± 119.70	300.51 ± 78.28	< .001[c]	645.93 ± 154.68	369.11 ± 73.43	< .001[c]	< .001[c]	< .001[c]
AOD_{750} (μm)	653.26 ± 140.10	376.44 ± 87.50	< .001[c]	842.63 ± 163.80	465.65 ± 73.86	< .001[c]	< .001[c]	< .001[c]
$TISA_{500}$ (μm²)	171504.51 ± 41985.55	115720.95 ± 32381.69	< .001[c]	244728.75 ± 63277.48	147229.20 ± 33404.29	< .001[c]	< .001[c]	< .001[c]
$TISA^{750}$ (μm²)	322312.50 ± 69997.99	199785.47 ± 50130.82	< .001[c]	439367.45 ± 93887.00	258558.11 ± 46750.51	< .001[c]	< .001[c]	< .001[c]

ACA = anterior chamber angle; ACW = anterior chamber width; AOD = angle opening distance; CLR = crystalline lens rise; SD = standard deviation; TIA = trabecular-iris angle; TISA = trabecular-iris space area
[a]Comparison of preoperative parameters between the two groups.
[b]Comparison of postoperative parameters between the two groups.
*[c]**P** < .05 is considered significant.*

and 2.09 ± 3.06% at the 6-month postoperative follow-up for the two groups, showing significant differences ($P < .05$). However, no eyes showed a decrease below 2,000 cells/mm² or experienced substantial loss. Our results regarding the decrease in ECD are consistent with previous studies.[16,32] Additionally, many studies have observed chronic loss of ECD during the postoperative follow-up period.[33] We will continue to follow up with patients in future research to monitor the extent of ECD loss. These results indicate that the implantation of the ICL-V4c in eyes with low ACD is both safe and effective.

As an intraocular refractive surgery, the evaluation of anterior segment parameters is crucial alongside assessing the safety and efficacy of ICL in visual correction. In the study by Sánchez-Trancón et al,[24] the morphology of the anterior chamber angle after ICL surgery was analyzed. It was found that patients with lower ACD and higher postoperative vault exhibited a narrower ACA. Additionally, correlations were observed between CLR and corneal sagittal height with vault height. In our study, OCT analysis revealed differences in CLR and ACA parameters between the two groups, along with a reduction in ACD and a narrowing of angle-related parameters postoperatively in both groups (all $P < .05$). In eyes with low ACD, the angle-related parameters decreased by 27.8%

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TABLE 3

Linear Regression Analysis to Determine the Correlations Between Preoperative Anterior Chamber Parameters and Vault

	Low ACD (< 2.8 mm, n = 96)								Normal ACD (≥ 2.8 mm, n = 44)							
	Univariate Analysis				Multivariate Analysis				Univariate Analysis				Multivariate Analysis			
Parameter	B	β	95% CI	*P*	B	β	95% CI	*P*	B	β	95% CI	*P*	B	β	95% Ci	*P*
WTW (mm)	97.346	0.164	-135.820, 330.512	.408	–	–	–	–	81.318	0.184	-211.143, 373.780	.571	–	–	–	–
ACD (μm)	0.398	0.216	0.009, 0.787	.045[a]	0.489	0.267	0.335, 0.642	< .001[c]	0.226	0.131	-0.790, 1.162	.621	–	–	–	–
ACW (μm)	-0.160	-0.296	-0.358, 0.038	.111	–	–	–	–	-0.074	-0.149	-0.452, 0.304	.689	–	–	–	–
CLR (μm)	-0.033	-0.038	-0.319, 0.253	.819	–	–	–	–	-0.158	-0.150	-0.507, 0.192	.365	–	–	–	–
Temporal																
ACA (°)	1.071	0.067	-5.218, 10.305	.517	–	–	–	–	-4.149	-0.121	-33.658, 25.361	.774	–	–	–	–
TIA_{500} (°)	7.832	0.260	0.752, 14.913	.031[a]	6.020	0.201	-0.001, 12.040	.050	19.009	0.709	-72.911, 110.930	.455	–	–	–	–
TIA_{750} (°)	-10.460	-0.350	-24.649, 3.730	.146	–	–	–	–	1.356	0.044	-121.469, 124.181	.982	–	–	–	–
AOD_{500} (μm)	-1.019	-0.629	-4.942, 2.903	.606	–	–	–	–	0.075	0.072	-6.004, 6.155	.980	–	–	–	–
AOD_{750} (μm)	0.347	0.302	-3.460, 4.154	.856	–	–	–	–	0.971	1.078	0.408, 1.533	.001[a]	-0.046	-0.042	-0.387, 0.296	.788
$TISA_{500}$ (μm^2)	-0.005	-1.112	-0.018, 0.008	.419	–	–	–	–	-0.002	-0.736	-0.004, 0.000	.020[a]	0.000	-0.096	-0.001, 0.001	.536
$TISA_{750}$ (μm^2)	0.005	1.771	-0.004, 0.013	.279	–	–	–	–	0.000	-0.222	-0.014, 0.013	.953	–	–	–	–
Nasal																
ACA (°)	3.442	0.075	-11.253, 18.137	.642	–	–	–	–	-1.064	-0.022	-31.641, 29.513	.943	–	–	–	–
TIA_{500} (°)	37.126	1.286	13.926, 60.327	.002[a]	1.315	0.046	-4.484, 7.114	.654	-13.314	-0.406	-105.306, 78.677	.767	–	–	–	–
TIA_{750} (°)	9.844	0.299	-53.788, 73.476	.759	–	–	–	–	103.538	2.843	34.632, 172.443	.004[a]	-12.317	-0.282	-25.343, 0.710	.063
AOD_{500} (μm)	-2.364	-1.501	-3.638, -1.090	< .001[a]	-0.046	-0.030	-0.362, 0.270	.774	-5.125	-4.073	-7.640, -2.609	< .001[a]	-0.409	-0.268	-0.866, 0.049	.079
AOD_{750} (μm)	0.907	0.672	-2.520, 4.334	.599	–	–	–	–	1.741	1.452	-3.856, 7.338	.526				
$TISA_{500}$ (μm^2)	0.007	1.646	-0.004, 0.019	.203	–	–	–	–	0.022	7.348	0.011, 0.034	< .001[a]	-0.001	-0.173	-0.002, 0.000	.260
$TISA_{750}$ (μm^2)	-0.005	-1.713	-0.012, 0.003	.235	–	–	–	–	-0.013	-6.317	-0.021, -0.005	.002[a]	-0.001	-0.211	-0.001, 0.000	.170

ACA = anterior chamber angle; ACW = anterior chamber width; AOD = angle opening distance; CLR = crystalline lens rise; TIA = trabecular-iris angle; TISA = trabecular-iris space area; WTW = white-to-white distance

[a]***P** values less than .05 are considered significant.*

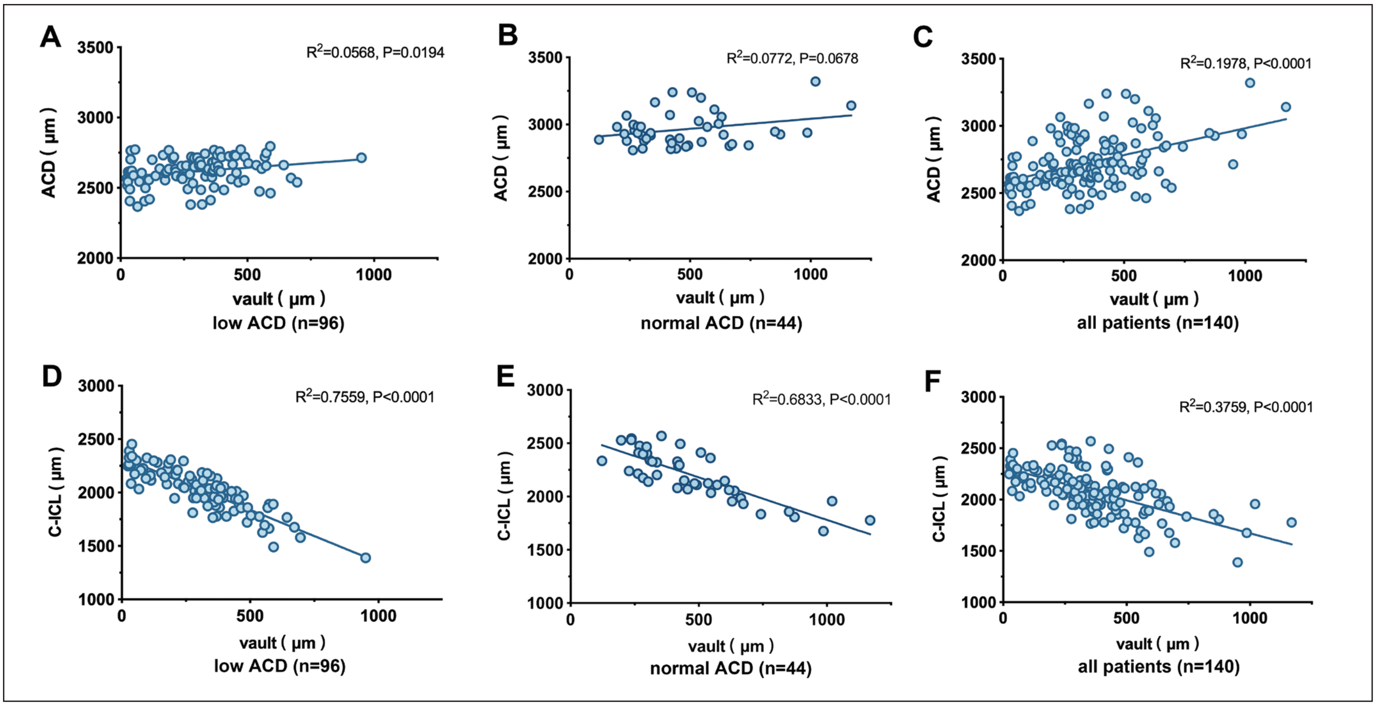

Figure 4. Scatter plots (A-F) showing the relationships between the preoperative anterior chamber depth (ACD), distance from cornea to implantable collamer lens (C-ICL), and vault in (A, D) the low ACD group, (B, E) the normal ACD group, and (C, F) all enrolled participants, respectively.

to 42.5%, whereas in those with normal ACD, the reduction was 25.4% to 44.8%. This result is broadly consistent with Sánchez-Trancón et al's analysis of anterior chamber angle structures.[24] Despite the ICL haptics' minimal effect on the angle due to its fixation in the ciliary sulcus post-implantation, support from the ICL induces a displacement of the pupil-iris complex toward the cornea, leading to a reduction in angle structures. Fernández-Vigo et al[34] used Fourier-domain OCT to examine changes in TIA on the nasal, temporal, and inferior sides, reporting a 34% to 42% reduction in angle size at 1 month postoperatively, with no change between 1 and 3 months. Liu et al[35] focused on patients with low ACD and lower baseline values, and reported a 28.4% reduction in TIA_{500} and a 27.3% reduction in AOD_{500} postoperatively using swept-source OCT. Furthermore, these studies revealed that while there were significant postoperative changes in anterior chamber structures, no structural alterations were observed over time. Hence, as demonstrated in the study by Choi et al,[36] understanding anterior chamber angle-related structures and developing models to predict postoperative parameters for ICL surgery is essential; this approach is necessary to prevent complications such as peripheral anterior synechiae or secondary angle-closure glaucoma in individuals undergoing ICL surgery.

To further investigate the influence of postoperative anterior chamber structures on the safety of ICL-V4c surgery in patients with low ACD, we conducted an additional regression analysis involving various anterior chamber parameters and vault. Our analysis revealed a significant correlation between ACD and C-ICL with the vault in eyes with low ACD (all P < .001). A study by Cerpa Manitos et al[3] yielded similar findings, demonstrating statistically significant differences in postoperative vault height among three patient groups with ACD of 3.13 ± 0.24, 3.29 ± 0.25, and 3.42 ± 0.29, respectively (all P < .05). This suggested that individuals with deeper ACD experienced higher vault. In a study by González-López et al[37] eyes with a high vault (> 750 µm) exhibited higher ACD (P < .001) compared to those with a low vault (< 100 µm). The observed linear correlation between vault and ACD was positive. Lee et al[38] observed a positive correlation between preoperative ACD and vault in 213 eyes (R = 0.270, P = .002). Notably, these studies focused on patients with ACD of 2.8 mm or greater, which presented slight deviations from our outcomes. We speculate this difference is due to the exclusive inclusion of patients using the 12.1 mm model of ICL-V4c in our study. Although this limitation affects the analysis of normal ACD, the distinct anatomy of patients with low ACD necessitated recommending only the 12.1-mm ICL model for all. To prevent bias in anterior chamber parameters due to variations in ICL models between the two study groups, larger ICL models were not included. Additionally, variations in results between studies

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TABLE 4

Comparison of Anterior Chamber Parameters Measurements of Recruited Eyes Between Low Vault and Normal Vault in Both Groups

Parameter	Low ACD (< 2.8 mm, n = 96), Mean ± SD (Range)			Normal ACD (≥ 2.8 mm, n = 44) , Mean ± SD (Range)		
	Vault < 250 μm (n = 37)	Vault ≥ 250 μm (n = 59)	*P*	Vault < 250 μm (n = 57)	Vault ≥ 250 μm (n = 39)	*P*
WTW (mm)	11.24 ± 0.29	11.08 ± 0.31	.014[a]	11.14 ± 0.09	11.18 ± 0.47	.869
ACD (μm)	2595.42 ± 100.57	2631.83 ± 99.45	.085	2948.35 ± 77.79	2966.53 ± 132.51	.767
ACW (μm)	11349.21 ± 379.88	11195.74 ± 339.63	.042[a]	11384.54 ± 208.70	11314.88 ± 417.64	.717
CLR (μm)	90.35 ± 216.92	2.528 ± 207.30	.036[a]	-342.60 ± 136.56	-320.10 ± 193.94	.804
Temporal						
ACA (°)	37.22 ± 4.89	38.33 ± 4.84	.282	45.55 ± 4.77	39.88 ± 5.68	.039[a]
TIA_{500} (°)	43.69 ± 7.28	45.89 ± 5.23	.089	61.75 ± 5.39	50.44 ± 6.38	< .001[a]
TIA_{750} (°)	41.77 ± 7.03	43.35 ± 5.59	.227	56.90 ± 5.22	47.81 ± 5.72	.002[a]
AOD_{500} (μm)	497.31 ± 137.46	529.08 ± 96.82	.188	945.16 ± 213.93	625.43 ± 148.50	< .001[a]
AOD_{750} (μm)	692.99 ± 184.74	724.45 ± 143.81	.353	1183.39 ± 228.68	853.27 ± 184.70	.001[a]
$TISA_{500}$ (μm^2)	174806.99 ± 44374.55	188783.15 ± 34481.78	.087	339232.20 ± 89073.94	233054.62 ± 59373.78	.001[a]
$TISA_{750}$ (μm^2)	335331.57 ± 80595.62	357350.36 ± 65406.52	.146	598765.80 ± 138930.45	432821.54 ± 94412.98	.001[a]
Nasal						
ACA (°)	33.87 ± 3.97	34.24 ± 4.15	.665	42.04 ± 3.28	36.74 ± 3.88	.006[a]
TIA_{500} (°)	42.84 ± 8.65	43.02 ± 4.81	.908	60.43 ± 5.35	50.21 ± 4.96	< .001[a]
TIA_{750} (°)	40.42 ± 7.42	40.37 ± 4.43	.971	55.50 ± 2.28	46.61 ± 4.83	< .001[a]
AOD_{500} (μm)	489.51 ± 164.74	474.00 ± 80.80	.596	892.63 ± 170.71	614.31 ± 122.36	< .001[a]
AOD_{750} (μm)	662.71 ± 184.62	647.34 ± 104.40	.646	1084.17 ± 88.44	811.67 ± 144.50	< .001[a]
$TISA_{500}$ (μm^2)	171059.43 ± 55077.13	171783.63 ± 31690.08	.942	320346.40 ± 74903.38	235034.18 ± 5560.04	.003[a]
$TISA_{750}$ (μm^2)	323185.62 ± 90545.49	321764.95 ± 54183.89	.932	554590.80 ± 77527.38	424595.23 ± 85854.90	.003[a]

ACA = anterior chamber angle; ACW = anterior chamber width; AOD = angle opening distance; CLR = crystalline lens rise; SD = standard deviation; TIA = trabecular-iris angle; TISA = trabecular-iris space area; WTW =white-to-white distance

[a]P values less than .05 are considered significant.

could arise from diverse observation methods. Future evaluations of anterior chamber structures should involve larger sample sizes and diverse observational devices. We will also continue to explore the selection of ICL models for patients with low ACD in subsequent research.

We found a positive correlation between ACD and vault (R^2 = 0.0568, P = .0194), among the 96 eyes with low ACD included in our study, with an average vault being 303.53 ± 184.72 μm. Notably, 37 cases (38.54%) demonstrated vault of less than 250 μm, exhibiting a significant distinction from the normal ACD group (P < .01). Lim et al[9] in a study involving 10 patients and 18 eyes with low ACD (2.71 ± 0.08 mm), reported that 8 cases (44%) had vault of less than 250 μm, with an average postoperative vault height of 331.83 ± 181.28 mm. After approximately 2 years of follow-up, no severe complications were observed, but two cases (11.1%) developed ASC. It is important to note that only the ICL-V4c was used in our study. In the research by Qian et al,[16] 163 eyes of 94 patients with low ACD (mean: 2.72 ± 0.06 mm) underwent ICL-V4c surgery, and after 2 years of follow-up, only 5 cases (0.03%) exhibited ASC. The specific reasons for postoperative ASC remain unclear. We speculate that the design of the central aperture in ICL-V4c promotes aqueous hu-

TABLE 5

Linear Regression Analysis to Determine the Correlations Between Preoperative Anterior Chamber Parameters and Different Vault

Parameter	Vault < 250 µm (n = 37)				Vault ≥ 250 µm (n = 59)			
	B	β	95% CI	*P*	B	β	95% CI	*P*
WTW (mm)	-14.996	-0.059	-252.466, 222.474	.896	246.107	0.590	19.051, 465.740	.032[a]
ACD (µm)	0.392	0.534	0.144, 0.641	.003[a]	0.533	0.404	-0.052, 1.117	.046[a]
ACW (µm)	0.048	0.220	-0.132, 0.228	.579	-0.176	-0.450	-0.379, 0.026	.087
CLR (µm)	0.027	0.078	-0.284, 0.338	.858	-0.009	-0.013	0.329, 0.311	.957
Temporal								
ACA (°)	0.338	0.022	-12.891, 13.567	.958	-7.208	-0.264	-25.617,11.201	.442
TIA_{500} (°)	-13.879	-1.361	-65.565, 37.808	.578	72.810	2.887	14.203, 131.418	.016[a]
TIA_{750} (°)	20.903	1.980	-61.062, 102.868	.598	-40.728	-1.742	-127.577, 46.239	.355
AOD_{500} (µm)	0.623	1.159	-2.677, 3.923	.695	-2.838	-2.072	-7.181, 1.533	.205
AOD_{750} (µm)	-0.507	-1.264	-3.438, 2.424	.720	0.285	0.308	-4.173, 4.730	.899
$TISA_{500}$ (µm^2)	0.002	1.370	0.001, 0.004	.011[a]	-0.005	-1.225	-0.019, 0.010	.525
$TISA_{750}$ (µm^2)	-0.001	-1.402	-0.002, 0.000	.018[a]	0.004	1.839	-0.006, 0.013	.447
Nasal								
ACA (°)	6.201	0.322	-9,171, 21.573	.407	-1.167	-0.037	-16.987, 14.615	.884
TIA_{500} (°)	18.517	5.599	7.082, 29.952	.002[a]	-30.068	-1.152	-88.104, 26.379	.289
TIA_{750} (°)	-12.219	-1.188	-71.373, 46.935	.668	-4.111	-0.139	-77.589, 69.705	.912
AOD_{500} (µm)	-1.008	-2.180	-1.617, -0.400	.002[a]	1.397	0.867	-3.231, 6.002	.551
AOD_{750} (µm)	0.034	0.082	-2.452, 2.520	.977	1.339	1.071	-3.000, 5.645	.544
$TISA_{500}$ (µm^2)	-0.001	-0.750	-0.010, 0.008	.816	0.002	0.590	-0.011, 0.016	.720
$TISA_{750}$ (µm^2)	0.001	1.403	-0.006, 0.008	.729	-0.003	-1.057	-0.011, 0.006	.573

ACA = anterior chamber angle; ACW = anterior chamber width; AOD = angle opening distance; CLR = crystalline lens rise; TIA = trabecular-iris angle; TISA = trabecular-iris space area
[a]*P values less than .05 are considered significant.*

mor circulation, significantly reducing the incidence of postoperative ASC. And notably, in Lim et al's study,[9] the two patients who developed ASC were both older than 40 years (45 and 47 years), with refractive errors exceeding 12.00 D, which are known significant risk factors for cataract formation. Ye et al[39] observed 52 individuals (104 eyes) older than 40 years who underwent ICL-V4c surgery, discovering a significant correlation between age and postoperative anterior lens density at 1 month, 3 months, and the final follow-up. In our study, we conducted comprehensive preoperative examinations and assessments on patients with low ACD, who were relatively young (30.92 ± 5.69 years), which is likely the reason why postoperative ASC was not observed in the current study. We will continue to follow up with patients with low ACD, collecting and analyzing data such as anterior lens density.

In this study, to investigate the anterior chamber characteristics associated with the normal vault, we further categorized patients with low ACD into two groups based on a vault threshold of 250 µm. Interestingly, as shown in **Table 4**, postoperative anterior chamber structural parameters with the low vault in patients with low ACD are smaller than those with normal vault, which is contrary to the data observed in patients with normal ACD. This may be attributed to the fact that the chamber angle mor-

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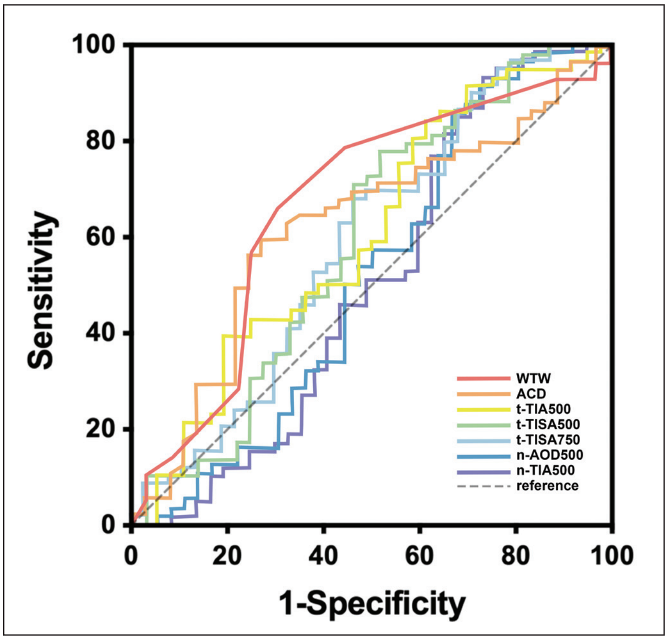

Figure 5. Receiver operating characteristic curves for parameters to separate normal vault from patients with low anterior chamber depth (ACD). n = nasal; ROC = receiver operating characteristic; t = temporal

phology is a result of the interaction between ACD and vault.[24] To find out the etiology of this difference, we further investigated the impact and predictability of various preoperative parameters on vault in patients with low ACD, by conducting an additional multiple regression analysis between each parameter and vault. Additionally, considering that ACD and WTW are typically recommended indicators for selecting the lens size preoperatively, we included WTW in the analysis and observed correlations between ACD, WTW, and parameters related to the anterior chamber angle with postoperative normal vault. Based on the result of these regression analyses in the eyes with low ACD only, we hypothesized that in cases of low ACD, patients with a smaller WTW had a higher vault. Currently, a contentious debate surrounds the determination of the minimum vault threshold. Zeng et al[40] proposed a secure range for the vault between 100 and 1,000 µm, whereas Maeng et al[41] recommended close monitoring when the vault falls below 52 µm. In contrast to the previously posited 250 µm vault safety threshold for patients with ACD of 2.8 mm or greater undergoing ICL surgery, the implantation of the ICL-V4c in patients with low ACD necessitates a continual supplementation of clinical data, active vault monitoring for long-term safety assurance, and a further and more detailed examination of surgical indications.

It is also noteworthy that the crystalline lens continues to grow in adulthood. Several studies have reported a progressive increase in lens thickness of approximately 0.15 to 0.20 mm per decade, and this growth is particularly pronounced in older individuals and patients with cataract.[42,43] Moreover, a large-scale study of a healthy population aged 30 to 78 years found that ACD decreases by approximately 0.007 mm per year.[44] As ACD decreases, potential risks may arise concerning the ACA, ECD, lens thickness, and anterior lens density. Therefore, greater caution is required when performing ICL implantation in patients with a low ACD, necessitating prolonged and rigorous postoperative follow-up.

TABLE 6

Result of ROC Analysis in Vault of Patients With Low ACD

Parameter	AUC	95% CI	*P*
WTW	0.666	0.548, 0.784	.007[a]
ACD	0.621	0.505, 0.738	.046[a]
t-TIA_{500}	0.605	0.483, 0.727	.091
t-$TISA_{500}$	0.597	0.474, 0.721	.110
t-$TISA_{750}$	0.590	0.467, 0.712	.141
n-AOD_{500}	0.519	0.388, 0.650	.761
n-TIA_{500}	0.505	0.374, 0.635	.937

ACD = anterior chamber depth; AUC = area under the curve; n = nasal; ROC = receiver operating characteristic; t = temporal; WTW = white-to-white distance

[a]P values less than .05 are considered significant.

In addition to the relatively short follow-up duration, several other limitations inherent in this study warrant consideration. Nevertheless, our study has several limitations. First, systemic errors in measurements from OCT images are unavoidable. The manual positioning of two-dimensional images concerning the scleral spur introduces subjectivity. In our research, we mitigated this by employing a blinding procedure, where the researcher was unaware of the clinical information of the patients to prevent bias. Furthermore, vault measurements were only recorded under certain light conditions; further studies regarding dynamic vault range will be interesting.[45,46] Additionally, for patients younger than 21 years, STAAR Surgical currently does not recommend ICL surgery. However, due to the demand of patients, we have engaged in communication and obtained informed consent. Rigorous follow-up will be conducted for these patients. Another limitation of the current study is that the follow-up period in this study was relatively short. Extending the duration of follow-up will provide a more comprehensive evaluation of the long-term safety of such procedures.

CONCLUSION

Our study indicates that the ICL-V4c is safe and efficacious in patients with low ACD. Patients with larger preoperative ACD and smaller WTW tend to have normal postoperative ICL vault. In patients with low ACD, there is a correlation between the normal vault and preoperative anterior chamber angle, WTW, and ACD, suggesting that measuring these anterior chamber parameters preoperatively may have predictive value for the resultant ICL vault postoperatively. Therefore, future studies should include a larger sample size and implement prolonged, rigorous follow-up evaluations of ACD, ACA, and lens-related parameters. This approach will provide more robust evidence concerning anterior chamber characteristics in patients with low ACD undergoing ICL-V4c surgery, including vault changes and their impact on visual outcomes for patients with low ACD.

AUTHOR CONTRIBUTIONS

Study concept and design (JO-U, ZW, MXW, KL); data collection (ZS, SW, SL, RW, YL, SD, YX, JH, KL); analysis and interpretation of data (ZS, KL); writing the manuscript (ZS, SW); critical revision of the manuscript (ZS, SL, RW, YL, SD, YX, JH, JO-U, ZW, MXW, KL); statistical expertise (ZS, SL, KL); administrative, technical, or material support (JO-U, ZW, MXW, KL); supervision (SW, ZW, KL)

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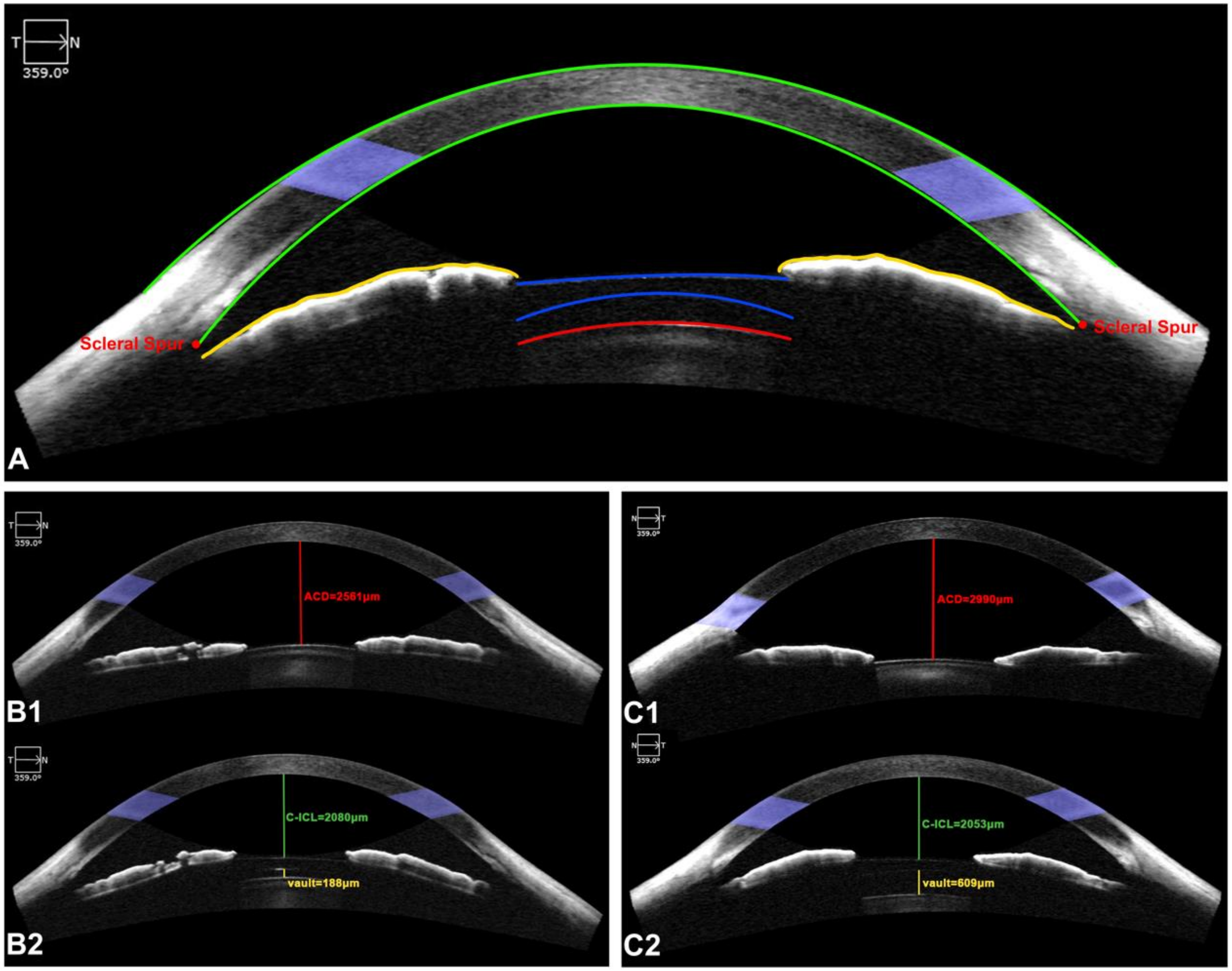

Figure A. Anterior Chamber OCT Structural Diagram. (A) The OCT diagram provides a clear representation of anterior chamber structures, delineated from top to bottom: corneal anterior and posterior surfaces (green lines), iris pigment epithelium (yellow lines), anterior and posterior surfaces of the ICL (blue lines), anterior lens capsule (red line), and red dots denoting the scleral spur. (B) Anterior chamber OCT images for patients with shallow ACD before surgery (B1) and after surgery (B2). (C) Anterior chamber OCT images for patients with normal ACD before surgery (C1) and after surgery (C2).

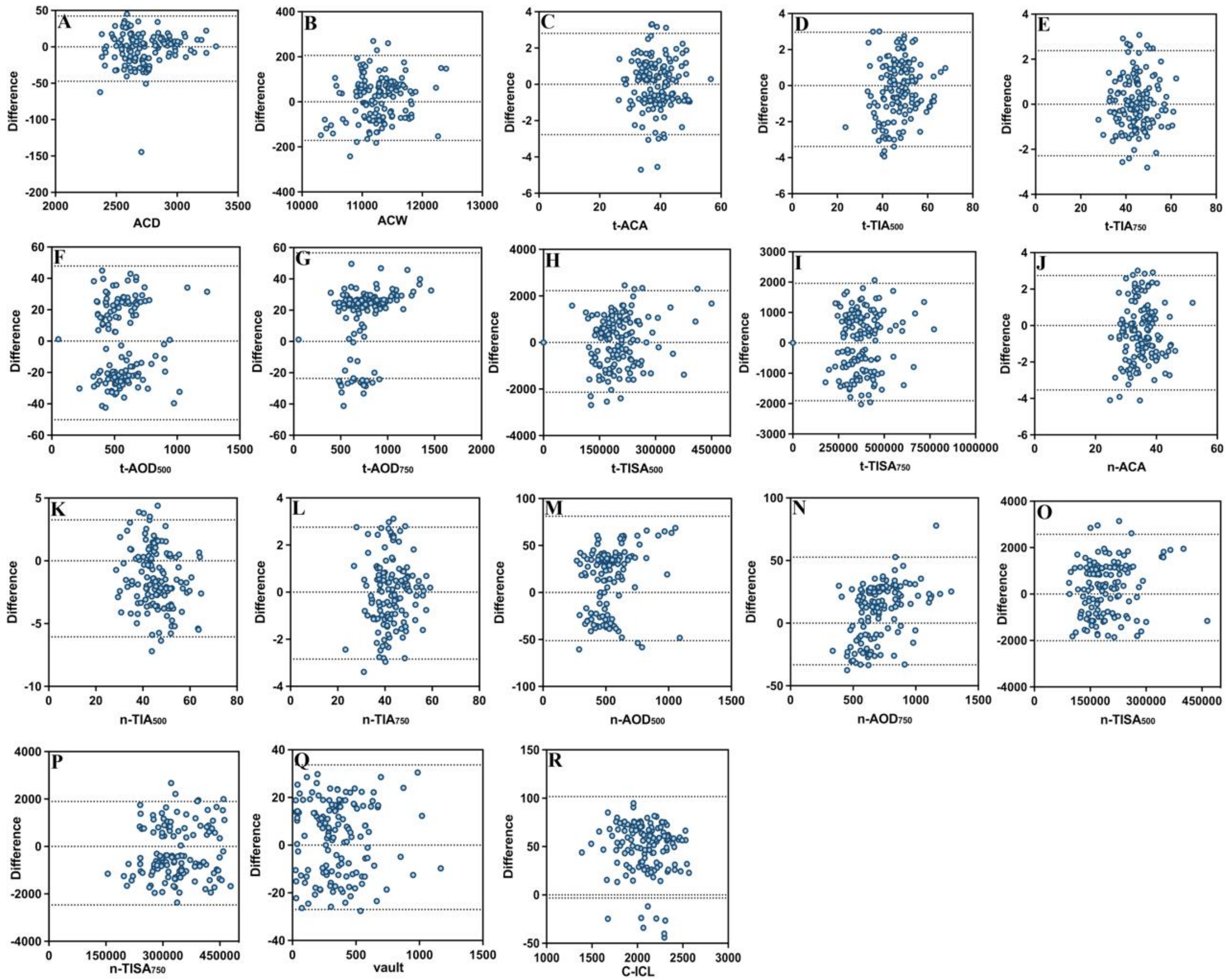

Figure B. Reproducibility differences in the measurement of anterior segment parameters. A~D: Preoperative Parameters; Q~R: Postoperative 6-month Parameters (vault and C-ICL).

Table A
Linear Regression Analysis to Determine the Correlations Between Postoperative 6-month Anterior Chamber Parameters and Vault

	Group 1 (ACD<2.8mm, n=96)								Group 2 (ACD≥2.8mm, n=44)							
	Univariate Analysis				Multivariate Analysis				Univariate Analysis				Multivariate Analysis			
paraments	**B**	β	**95%CI**	***P* value**	**B**	β	**95%CI**	***P* value**	**B**	β	**95%CI**	***P* value**	**B**	β	**95%CI**	***P* value**
ACD	0.093	0.052	-0.272, 0.458	0.616					0.504	0.307	0.017, 0.991	0.043	0.936	0.569	0.857, 1.014	<0.001*
C-ICL	-0.771	-0.869	-0.860, -0.681	<0.001	-0.725	-0.818	-0.818, 0.632	<0.001*	-0.855	-0.827	-1.036, -0.674	<0.001	-0.992	-0.959	-1.056, -0.928	<0.001*
ACW	-0.094	-0.204	-0.185, -0.002	0.046	-0.037	-0.080	-0.077, 0.004	0.077	0.129	0.234	-0.038, 0.296	0.126				
Temporal																
ACA	-22.721	-0.527	-30.231, -15.211	<0.001	-0.765	-0.018	-5.702, 4.173	0.759	-21.720	-0.332	-40.921, -2.519	0.028	-2.741	-0.042	-7.868, 2.385	0.285
TIA_{500}	-5.264	-0.176	-11.296, 0.768	0.086					-15.068	-0.383	-26.394, -3.742	0.010	-5.619	-0.143	-18.278, 7.040	0.373
TIA_{750}	-12.567	-0.332	-19.880, -5.254	0.001	-9.779	-0.258	-32.097, 12.540	0.386	-21.559	-0.430	-35.640, -7.478	0.004	-0.028	-0.001	-21.542, 21.486	0.998
AOD_{500}	-0.457	-0.191	-0.938, 0.023	0.062					-0.983	-0.346	-1.812, -0.153	0.021	0.232	0.082	-0.637, 1.100	0.591
AOD_{750}	-0.701	-0.322	-1.123, -0.279	0.001	0.504	0.232	-0.771, 1.780	0.434	-1.070	-0.397	-1.841, -0.299	0.008	0.173	0.064	-0.938, 1.285	0.753
$TISA_{500}$	0.000	-0.078	-0.002, 0.001	0.451					-0.002	-0.262	-0.004, 0.000	0.085				
$TISA_{750}$	-0.001	-0.191	-0.002, 0.000	0.062					-0.002	-0.339	-0.003, 0.000	0.024	0.000	-0.024	-0.001, 0.001	0.755
Nasal																
ACA	-28.647	-0.595	-36.576, -20.719	<0.001	-6.002	-0.125	-12.405, 0.402	0.066	-25.449	-0.431	-42.041, -8.857	0.003	0.816	0.014	-2.726, 4.357	0.643
TIA_{500}	-6.048	-0.216	-11.657, -0.438	0.035	10.595	0.378	-11.311, 32.501	0.339	-3.048	-0.073	-15.927, 9.831	0.635				
TIA_{750}	-10.923	-0.322	-17.494, -4.352	0.001	0.063	0.002	-34.455, 34.580	0.997	-11.757	-0.212	-28.649, 5.136	0.168				
AOD_{500}	-0.487	-0.206	-0.960, -0.014	0.044	-0.802	-0.340	-2.687, 1.084	0.400	-0.131	-0.041	-1.131, 0.869	0.793				
AOD_{750}	-0.697	-0.330	-1.105, -0.289	0.001	0.030	0.014	-2.087, 2.148	0.977	-0.700	-0.219	-1.671, 0.270	0.153				
$TISA_{500}$	-0.001	-0.116	-0.002, 0.000	0.258					0.000	0.062	-0.002, 0.003	0.689				
$TISA_{750}$	0.000	0.115	0.000, 0.001	0.263					0.000	-0.009	-0.002, 0.002	0.955				

* *P* values less than 0.05 are considered significant.

Table B
Comparison of Vault in Two Groups

	Group 1 (ACD<2.8mm)	Group 2 (ACD≥2.8mm)	x^2	*P* value
vault<250µm (n, %)	37 (38.54%)	5 (11.36%)	10.61	<0.01
vault≥250µm (n, %)	59 (61.46%)	39 (88.64%)		