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# The Relationship of Corneal White-to-White and Anterior Chamber Depth on Implantable Collamer Lens Vaulting

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## Abstract

This comparative prospective study examined the relationship between preoperative anterior segment biometry and central vault after implantation of the Implantable Collamer lens (ICL). **Patients and methods:** This study included 60 eyes of 30 patients treated with an ICL at a private practice. Baseline refractive error, white-to-white (WTW) corneal diameter, central corneal thickness and anterior chamber depth (ACD) were measured and compared with the lens size used and the central vault measured using anterior segment OCT following surgery. To determine statistically significant correlations, we used Pearson correlation. We also used ANOVA to compare eyes by ICL size and determine how vault correlated with size within each group. **Results**: Mean postoperative vault was 495.95µm±244.182µm (range 40–1070µm), and it was found to be significantly correlated with ACD and pachymetry. In group 2, vault correlated significantly with WTW (R=-0.461, p=.009), ACD (R=0.491, p=.005) and pachymetry (R=0.558, p=.001). In group 3, vault was significantly associated with preoperative SEQ (R=-0.428, p=0.026), pachymetry (R=0.504, p=0.007) and ICL SEQ (R=-0.472, p=.013). **Conclusion**: ACD and pachymetry were significantly correlated with ICL vault in the overall sample. WTW was not significantly correlated with ICL vault in the overall sample. These findings do not support identifying WTW as a significant correlate of vault in the overall sample.

## Introduction

Currently, the most common procedure performed is laser-assisted in situ keratomileusis (LASIK). Other corneal-based methods are less well adapted for highly myopic eyes or eyes with thin corneas

because they carry the risk of a visual disturbance known as iatrogenic keratectasia [1]. The corneal ablation can also compromise the optical quality of the cornea, and thus the quality of vision [2,3].

If corneal surgery is not an option, two other options are available: phakic intraocular lens (pIOL) implantation and refractive lens exchange (RLE). RLE safely and effectively corrects high ametropia, especially in presbyopic patients [4,5].

The Visian implantable collamer lens (ICL; Staar Surgical Co.) is the most studied and has been reported as a safe, predictable procedure for correcting moderate to high ametropia [6-11]. Collamer is a collagen-containing copolymer composed of collagen (0.4%), polyhydroxyethyl methacrylate (60%), water (37.5%) and benzophenone (3.3%). The eye tolerates it well, and it is safe in the posterior chamber [7,9,11].

The first ICL implantations were performed in 1993. Early lenses were in close contact with the crystalline lens, prompting further lens design changes. The first model kept the optic zone diameter constant and changed the footplate size; the second reversed this, changing the optic diameter while keeping the footplates constant; the third generation changed the optic diameter.

The V4 model, introduced in 1998, has a posterior concave surface with an 11 mm radius, increasing the space between the posterior apex of the ICL (central vault) and the apex of the crystalline lens. The V4B variant includes four new full-thickness holes in the footplates, two at each end, to enhance water flow in and out [12]. The latest version (V4C) was introduced at the 2011 ESCRS meeting in Vienna and features a small central port on the visual axis that does not interfere with pupillary block or affect optical quality [13].

Sizing is an important aspect of treatments performed preoperatively as it determines the position and stability of the lens. An enlarged ICL forces the ciliary sulcus to work harder, brings additional peripheral contact with the crystalline lens, pushes the peripheral iris forward and may lead to rubbing of one or more peripheral surface areas of the iris and dispersion of iris pigment. If the lens is undersized, however, it creates a low vault, touches the crystalline lens in the centre, and is less stable [14-16]. Therefore, this study compared anterior segment parameters (ASP) with vault after ICL implantation, focusing primarily on WTW and ACD.

## Patients and method

### Study design and eligibility

The patients with myopia and compound myopic astigmatism seen for ICL surgery (V4b; Staar Surgical, Switzerland) were evaluated in this study. We performed surgery at Jenna Ophthalmic Centre from 2014 to 2015. We identified three patient groups based on the size of the implanted ICL.

Surgery was considered as an option in the following patients:

- Be between the ages of 21 and 45 years;
- ACD from the centre of at least 2.80 mm;
- Endothelial cell density of at least 2,000 endothelial cells per $mm^2$;
- Refractive error stable for at least one year, with spectacle sphere from –2.50 to –20.00 D and cylinder below –6.0 D.

Patients were excluded if they had recurrent or active ocular disease, Fuchs' corneal dystrophy, synechiae, uveitis, pigment dispersion syndrome, glaucoma, lens dislocation, retinopathy, macular degeneration or keratoconus; if they had an autoimmune, connective tissue or other systemic disease; or if they were pregnant or breastfeeding.

### Pre-operative evaluation or surgery

The preoperative workup comprised uncorrected (UDVA) and corrected (CDVA) distance visual acuity, subjective and objective refraction, slit-lamp examination, Scheimpflug topography (Galilei, Ziemer), WTW measurement with callipers, intraocular pressure, gonioscopy and retinal

examination. We used each patient's data to calculate lens power and size with the manufacturer's online calculation software (Staar Surgical).

The entire surgery was performed under topical anaesthesia. The Visian V4b lens (toric or spherical) was placed into the ciliary sulcus via a 3.0 mm clear corneal incision made in the temporal cornea. Patients were treated with topical antibiotics, lubricants and decreasing doses of steroids following surgery.

**Follow-up and vault measurement.**
We examined patients at 4 hours, 1 day, 3 days, 1 week, and 1 month after surgery. We performed biomicroscopy and IOP measurements, and defined the vault as the central distance between the anterior surface of the crystalline lens and the posterior surface of the pIOL, measured by optical coherence tomography (RTVue-100, Optovue, USA) at the 1-month visit. We took all vault measurements at this visit under the same lighting conditions, without cycloplegia, leaving the anterior surface of the crystalline lens and the pIOL undisturbed and avoiding changes in vault value due to accommodation. One technician examined each eye, made multiple measurements, and recorded the average.

**Statistical analysis**
We coded and analysed the data using SPSS 21.0. We performed a descriptive summary of the preoperative parameters. We used ANOVA to compare eyes by ICL size, and Pearson correlation to assess the relationship between each parameter and vault size. All tests were two-tailed, and a p-value below 0.05 was considered statistically significant.

## Results

### Preoperative parameters

The study included 60 eyes of 30 patients, 18 male (60%) and 12 female (40%), with a mean age of 31.21±7.48 years (range 21–45). A total of 17 eyes were treated with a toric ICL, and 43 eyes were treated with a spherical ICL.

**Table 1. Preoperative parameters**

| Parameter | Mean±SD | Min. | Max. |
|---|---|---|---|
| **WTW (mm)** | 11.597±0.272 | 11.10 | 12.10 |
| **Central pachymetry (µm)** | 496.33±29.961 | 438 | 562 |
| **ACD (mm)** | 3.2317±0.211 | 2.80 | 3.70 |
| **ICL size (mm)** | 12.855±0.331 | 12.1 | 13.3 |

### Refractive and visual outcome

Preoperative spherical equivalent (SEQ) ranged from -20.0 to -4.0 D. Refractive results are shown in Table 2.

**Table 2. Refractive and visual outcome**

| Parameter | Preoperative | Postoperative | P |
|---|---|---|---|
| **SEQ** | -10.803 ± 3.714 | -0.709 ± 0.618 | 0.001 |
| **BCVA (LogMAR)** | 0.266 ± 0.169 | | |
| **UCVA (LogMAR)** | | 0.140 ± 0.115 | |

## Analysis by ICL size

The ICL size groups were significantly different for WTW and for preoperative ACD, with higher WTW and shallower ACD being favoured for the larger lenses. No significant differences were found in the other clinical parameters, and none were found in vault (Table 3).

**Table 3. Clinical parameters by ICL size (ANOVA)**

| Parameter | Group 1 (12.1 mm) | Group 2 (12.6 mm) | Group 3 (13.2 mm) | p value |
|---|---|---|---|---|
| **WTW** | 11.100±.000* | 11.419±.183* | 11.837±.115* | 0.001 |
| **ACD** | 2.850±.071* | 3.188±.226 | 3.310±.175* | 0.003 |
| **Pachy** | 460.500±.707 | 499.387±29.718 | 495.481±30.122 | 0.204 |
| **Pre SEQ** | -15.500±1.414 | -11.117±3.887 | -10.093±3.383 | 0.109 |
| **Pre BCVA** | 0.500±.144 | 0.250±.154 | 0.268±.179 | 0.127 |
| **Post UCVA** | 0.159±.088 | 0.145±.104 | 0.139±.131 | 0.963 |
| **Postop SEQ** | -1.0±.354 | -0.663±.868 | -0.495±.584 | 0.517 |
| **Vault** | 330.500±47.376 | 464.484±261.716 | 544.333±224.647 | 0.292 |

WTW, white-to-white; ACD, anterior chamber depth; Pachy, central corneal thickness; Pre_SEQ, preoperative spherical equivalent; Pre_BCVA, preoperative best-corrected visual acuity; Post UCVA, postoperative uncorrected visual acuity; Postop SEQ, postoperative spherical equivalent. *Significant difference on Bonferroni testing.

## Lens vault

The mean postoperative vault was 495.95±244.182 µm (range 40–1070 µm) and was significantly correlated with ACD and pachymetry. In subgroup analysis, group 2 showed significant correlations between vault and WTW (R=-0.461, p=.009), ACD (R=0.491, p=.005) and pachymetry (R=0.558, p=.001). In group 3, vault correlated significantly with preoperative SEQ (R=-0.428, p=0.026), pachymetry (R=0.504, p=.007) and ICL SEQ (R=-0.472, p=.013).

Table 4 shows the correlations for the entire sample.

Complications: In this sample, we detected no complications; however, follow-up will require more time.

**Table 4. Pearson correlation between preoperative parameters and ICL vault**

| Parameter | R | p value |
|---|---|---|
| **WTW** | 0.026 | 0.843 |
| **ACD** | 0.452 | 0.001* |
| **Pachymetry** | 0.525 | 0.001* |
| **ICL size** | 0.201 | 0.124 |
| **ICL SEQ** | -0.269 | 0.038* |
| **SEQ** | -0.256 | 0.048* |
| **Preop CDVA** | 0.043 | 0.746 |
| **Postop UDVA** | 0.118 | 0.374 |

WTW, white-to-white; ACD, anterior chamber depth; Pachymetry, central corneal thickness; SEQ, spherical equivalent; ICL SEQ, spherical equivalent of the implanted lens; Preop CDVA, preoperative corrected distance visual

acuity; Postop UDVA, postoperative uncorrected distance visual acuity. *Significantly different using Bonferroni testing

## Discussion

According to our results, the ICL may be an effective treatment for high myopia in keratorefractive surgery ineligible eyes. We observed both clinically and statistically significant improvements in visual acuity and refraction, as shown in Table 2. Sixty-eight per cent of the treated eyes achieved 6/9 or better, and 31 per cent of the treated eyes achieved 6/18 or better. Vault correlated significantly with ACD (R=0.452, p=0.001), pachymetry (R=0.525, p=0.001) and SEQ (R=-0.256, p=0.048). This correlation between vault and ACD is consistent with previous studies by Seo et al. [15] and Alfonso et al. [16], which also found ACD to be a significant factor in vault. The relationship with SEQ is similar to Alfonso et al. [16], who also reported that vault was associated with higher myopia. To the best of our knowledge, no previous study has reported a correlation between vault and pachymetry, and pachymetry did not differ among the ICL size groups in our sample (Table 3). There was no significant correlation between vault and WTW, ICL size, preoperative CDVA or postoperative UDVA.

The manufacturer recommends that a myopic eye should have a pIOL distance 0.5 to 1.0 mm greater than the WTW distance. This will produce a vault that extends across the entire anterior surface of the crystalline lens, about 1.0-1.5 times the central corneal thickness at slit-lamp examination [17] or approximately 400 to 600 µm [18]. Achieving this requires selecting the correct lens size. A low vault (less than 250 µm) is common after surgery because the tunnel diameter is underestimated. With a low vault, there is a risk of contact between the ICL and the crystalline lens or that the flow of the aqueous humour is disturbed, affecting the nutrition and metabolism of the natural lens [20-22].

An unusually large vault (about 750 µm) [19] can cause angle closure or pigmentary glaucoma [23,24]. The anterior segment is also not static; it is dynamic due to changes in eye biometry and accommodation, which affect the space between the posterior surface of the cornea and the anterior surface of the crystalline lens, and hence the vault [25,26]. There is no agreement on the optimum vault range. Zeng et al. [27] proposed a safe range of 100 to 1000 µm. Rayner et al. [28] considered 50 µm the generally accepted minimum and did not impose an upper limit, provided the anterior chamber angle structure and function remain normal.

The initial proposal by Bhikoo et al. [29] was that the minimum should be 200 µm, and this later became 150 µm. In our study, the vault averaged 495.95±244.182 µm (range 40–1070 µm). In a few eyes, it fell outside the desirable range and exceeded the manufacturer's recommendation: one eye was 40 µm (below the low range), and two eyes were 1015 and 1070 µm (above the high range). None of these eyes developed any complications, and all patients were happy with their vision. Four ICL sizes were available (12.1, 12.6, 13.2 and 13.7 mm, in steps of about 0.5 mm), and each was assigned by WTW: 12.1 mm for 11.0–11.5 mm, 12.6 mm for 11.5–12.0 mm, 13.2 mm for 12.0–12.5 mm, and 13.7 mm for values above 12.5 mm.

The subgroup analysis divided eyes into three groups: group 1 (12.1 mm) with 2 eyes, group 2 (12.6 mm) with 31 eyes, and group 3 (13.2 mm) with 27 eyes. We did not use the 13.7 mm lens on any eye. The majority of eyes were in groups 2 and 3 and are consistent with the report of Rüfer et al. [30], who reported a mean corneal diameter of 11.71±0.42 mm with no significant difference between the genders; our values were within this normal range, and a WTW of 11.1 mm is considered a normal variation.

We saw significant differences between size groups for WTW and ACD (larger lenses for wider WTW and deeper ACD), but not for the other clinical parameters or the vault. The refractive error and the diameter between the cornea's anterior and posterior surfaces (WTW) are used to determine

the size of an ICL. Other investigators have reported that an optimal vault also considers the sulcus-to-sulcus diameter (measured using ultrasound biomicroscopy, UBM) [31,32]. If the ICL size does not match the ciliary sulcus, it creates either a too-low or too-high vault. Lee et al. [31] showed that sulcus-to-sulcus diameter, ICL size, and keratometry values affect vault. Despite this, no method has been shown to predict vault better than WTW and ACD, the two most popular and studied vaulting methods.

**Limitations**

Several opticians measured WTW, so measurement error is possible when sizing the ICL and creating the resulting vault. Furthermore, poor attendance at long-term follow-up prevented us from identifying late adverse effects.

**Conclusion**

The relatively small sample size and the inclusion of only two eyes in group 1 may limit the generalizability of the findings. Furthermore, the study was conducted in a single clinical setting using the Visian V4b ICL, which may limit the applicability of the results to other settings and ICL models. Future studies involving larger samples and multiple clinical centres are needed to confirm these findings.

ACD was significantly correlated with ICL vault in the overall sample. WTW was not significantly correlated with ICL vault in the overall sample, although a significant negative correlation was observed in group 2. Accurate preoperative assessment may help guide ICL sizing and vault prediction.

**Refrences**


1. Kamiya K, Shimizu K, Kawamorita T. Changes in vaulting and the effect on refraction after phakic posterior chamber intraocular lens implantation. J Cataract Refract Surg. 2009;35(9):1582–1586. https://doi.org/10.1016/j.jcrs.2009.03.052
2. Kohnen T, Kook D, Morral M, Güell JL. Phakic intraocular lenses: part 2: results and complications. J Cataract Refract Surg. 2010;36(12):2168–2194. https://doi.org/10.1016/j.jcrs.2010.10.007
3. Sanders DR. Matched population comparison of the Visian implantable collamer lens and standard LASIK for myopia of −3.00 to −7.88 diopters. J Refract Surg. 2007;23(6):537–553. https://doi.org/10.3928/1081-597X-20070601-02
4. Alió JL, Tavolato M, De la Hoz F, et al. Near vision restoration with refractive lens exchange and pseudoaccommodating and multifocal refractive and diffractive intraocular lenses: comparative clinical study. J Cataract Refract Surg. 2004;30(12):2494–2503. https://doi.org/10.1016/j.jcrs.2004.04.052
5. Packer M, Fine IH, Hoffman RS. Refractive lens exchange with the array multifocal intraocular lens. J Cataract Refract Surg. 2002;28(3):421–424. https://doi.org/10.1016/S0886-3350(01)01093-8
6. Arne JL, Lesueur LC. Phakic posterior chamber lenses for high myopia: functional and anatomical outcomes. J Cataract Refract Surg. 2000;26(3):369–374. https://doi.org/10.1016/S0886-3350(99)00417-4
7. Alfonso JF, Baamonde B, Fernández-Vega L, et al. Posterior chamber collagen copolymer phakic intraocular lenses to correct myopia: five-year follow-up. J Cataract Refract Surg. 2011;37(5):873–880. https://doi.org/10.1016/j.jcrs.2010.11.040
8. Allan BD, Argeles-Sabate I, Mamalis N. Endophthalmitis rates after implantation of the intraocular Collamer lens: survey of users between 1998 and 2006. J Cataract Refract Surg. 2009;35(4):766–769. https://doi.org/10.1016/j.jcrs.2008.12.027

9. Lackner B, Pieh S, Schmidinger G, et al. Long-term results of implantation of phakic posterior chamber intraocular lenses. J Cataract Refract Surg. 2004;30(11):2269–2276. https://doi.org/10.1016/j.jcrs.2004.07.018
10. Pesando PM, Ghiringhello MP, Di Meglio G, Fanton G. Posterior chamber phakic intraocular lens (ICL) for hyperopia: ten-year follow-up. J Cataract Refract Surg. 2007;33(9):1579–1584. https://doi.org/10.1016/j.jcrs.2007.05.030
11. Sanders DR. Actual and theoretical risks for visual loss following use of the implantable contact lens for moderate to high myopia. J Cataract Refract Surg. 2003;29(7):1323–1332. https://doi.org/10.1016/S0886-3350(02)02040-0
12. Fernandes P, González-Méijome JM, Madrid-Costa D, et al. Implantable collamer posterior chamber intraocular lenses: a review of potential complications. J Refract Surg. 2011;27(10):765–776. https://doi.org/10.3928/1081597X-20110617-01
13. Shimizu K, Kamiya K, Igarashi A, Shiratani T. Early clinical outcomes of implantation of posterior chamber phakic intraocular lens with a central hole (Hole ICL) for moderate to high myopia. Br J Ophthalmol. 2012;96(3):409–412. https://doi.org/10.1136/bjophthalmol-2011-300148
14. Abela-Formanek C, Kruger AJ, Dejaco-Ruhswurm I, Pieh S, Skorpik C. Gonioscopic changes after implantation of a posterior chamber lens in phakic myopic eyes. J Cataract Refract Surg. 2001;27(12):1919–1925. https://doi.org/10.1016/S0886-3350(01)01229-9
15. Seo JH, Kim MK, Wee WR, Lee JH. Effects of white-to-white diameter and anterior chamber depth on implantable collamer lens vault and visual outcome. J Refract Surg. 2009;25(8):730–738. https://doi.org/10.3928/1081597X-20090707-08
16. Alfonso JF, Fernández-Vega L, Lisa C, et al. Central vault after phakic intraocular lens implantation: correlation with anterior chamber depth, white-to-white distance, spherical equivalent, and patient age. J Cataract Refract Surg. 2012;38(1):46–53. https://doi.org/10.1016/j.jcrs.2011.07.035
17. Implantable Contact Lens in Treatment of Myopia (ITM) Study Group. US Food and Drug Administration clinical trial of the implantable contact lens for moderate to high myopia. Ophthalmology. 2003;110(2):255–66. https://doi.org/10.1016/S0161-6420(02)01771-2
18. Alfonso JF, Lisa C, Palacios A, Fernandes P, González-Méijome JM, Montés-Micó R. Objective vs subjective vault measurement after myopic implantable collamer lens implantation. Am J Ophthalmol. 2009;147(6):978–983. https://doi.org/10.1016/j.ajo.2009.01.006
19. Güell JL, Morral M, Kook D, Kohnen T. Phakic intraocular lenses: part 1: historical overview, current models, selection criteria, and surgical techniques. J Cataract Refract Surg. 2010;36(11):1976–1993. https://doi.org/10.1016/j.jcrs.2010.08.014
20. Sanders DR. Anterior subcapsular opacities and cataracts 5 years after surgery in the Visian implantable collamer lens FDA trial. J Refract Surg. 2008;24(6):566–570. https://doi.org/10.3928/1081597X-20080601-04
21. Menezo JL, Peris-Martínez C, Cisneros-Lanuza AL, Martínez-Costa R. Rate of cataract formation in 343 highly myopic eyes after implantation of three types of phakic intraocular lenses. J Refract Surg. 2004;20(4):317–324. https://doi.org/10.3928/1081-597X-20040701-03
22. Bleckmann H, Keuch RJ. Results of cataract extraction after implantable contact lens removal. J Cataract Refract Surg. 2005;31(12):2329–2333. https://doi.org/10.1016/j.jcrs.2005.05.028
23. Smallman DS, Probst L, Rafuse PE. Pupillary block glaucoma secondary to posterior chamber phakic intraocular lens implantation for high myopia. J Cataract Refract Surg. 2004;30(4):905–907. https://doi.org/10.1016/j.jcrs.2003.09.019
24. Chung TY, Park SC, Lee MO, Ahn K, Chung ES. Changes in iridocorneal angle structure and trabecular pigmentation with STAAR implantable collamer lens during 2 years. J Refract Surg. 2009;25(3):251–258. https://doi.org/10.3928/1081597X-20090301-03
25. Alfonso JF, Lisa C, Abdelhamid A, Fernandes P, Jorge J, Montés-Micó R. Three-year follow-up of subjective vault following myopic implantable collamer lens implantation. Graefes Arch Clin Exp Ophthalmol. 2010;248(12):1827–1835. https://doi.org/10.1007/s00417-010-1322-0

26. Lege BA, Haigis W, Neuhann TF, Bauer MH. Age-related behaviour of posterior chamber lenses in myopic phakic eyes during accommodation measured by anterior segment partial coherence interferometry. J Cataract Refract Surg. 2006;32(6):999–1006. https://doi.org/10.1016/j.jcrs.2006.02.018
27. 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. https://doi.org/10.1016/j.jcrs.2014.06.036
28. Rayner SA, Bhikoo R, Grey T. Spherical implantable collamer lenses for myopia and hyperopia: 126 eyes with 1-year follow-up. Clin Exp Ophthalmol. 2010;38(1):21–26. https://doi.org/10.1111/j.1442-9071.2010.02192.x
29. Bhikoo R, Rayner S, Grey T. Toric implantable collamer lens for patients with moderate to severe myopic astigmatism: 12-month follow-up. Clin Exp Ophthalmol. 2010;38(5):467–474. https://doi.org/10.1111/j.1442-9071.2010.02273.x
30. Rüfer F, Schröder A, Erb C. White-to-white corneal diameter: normal values in healthy humans obtained with the Orbscan II topography system. Cornea. 2005;24(3):259–261. https://doi.org/10.1097/01.ico.0000148312.01805.53
31. Lee DH, Choi SH, Chung ES, Chung TY. Correlation between preoperative biometry and posterior chamber phakic Visian implantable collamer lens vaulting. Ophthalmology. 2012;119(2):272–277. https://doi.org/10.1016/j.ophtha.2011.07.047
32. Reinstein DZ, Lovisolo CF, Archer TJ, Gobbe M. Comparison of postoperative vault height predictability using white-to-white or sulcus diameter-based sizing for the Visian implantable collamer lens. J Refract Surg. 2013;29(1):30–35. https://doi.org/10.3928/1081597X-20121210-02