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Rotational stability, centration, and patient satisfaction with a trifocal toric intraocular lens

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Purpose: To evaluate the rotational stability, decentration, visual outcomes, and patient satisfaction after bilateral implantation of a trifocal toric intraocular lens (IOL), Clareon PanOptix Toric.

Setting: San Carlos Hospital, Madrid, Spain.

Design: Prospective, single-center, observational, noncomparative.

Methods: Patients aged 50 years or older suitable for cataract surgery without comorbidities and with regular corneal astigmatism >1.50 diopters (D) were bilaterally implanted with the Clareon PanOptix Toric IOL and followed up for 3 months. Outcomes measured included IOL displacement and rotation, quantified by the PIOLET software. In addition, refraction and uncorrected visual acuity at far (4 m) were measured, along with corrected visual acuities, monocular and binocular, at far (corrected visual acuity [CDVA]), intermediate (DCIVA), and near (DCNVA) distances.

Results: A total of 80 eyes from 40 patients were included in this study. At 3 months, the mean rotation was 1.04 ± 0.97 degrees, and the mean displacement was 0.19 ± 0.36 mm along the *x* axis and 0.19 ± 0.25 mm along the *y* axis. The postoperative spherical equivalent was −0.09 ± 0.35 D. Binocularly, the mean visual acuities were CDVA, −0.03 ± 0.05 logMAR; DCIVA, 0.07 ± 0.08 logMAR; and DCNVA, 0.09 ± 0.07 logMAR. Regarding satisfaction, 97% of patients indicated they were either very satisfied or fairly satisfied.

Conclusions: The bilateral implantation of the Clareon PanOptix Toric IOL demonstrated excellent rotational stability, minimal decentration, and effective astigmatism correction. It provided strong visual acuity outcomes and high patient satisfaction, making it a viable option for patients seeking spectacle independence.

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It is well known that for toric intraocular lens (IOL) implantation to yield optimal results, the lens must be implanted on the correct axis and remain stable on that axis over time. To achieve this, certain fundamental requirements must be met.[1] First, the capsular bag must be intact at the time of implantation. In addition, the capsulorhexis should be well-centered to ensure symmetrical IOL fixation and even distribution of forces. Moreover, the IOL must be properly centered during surgery.[2] Therefore, in cases with zonular instability, toric lenses may not be the best option due to potential stability issues.

One of the main factors contributing to the rotation of toric IOLs is axial length, with greater rotation reported in longer eyes.[3,4] A strong correlation has also been demonstrated between rotation and capsular bag dimensions.[5] The design of the IOL, particularly the haptics and overall diameter, plays a critical role in ensuring stability within the capsular bag and preventing postoperative rotation, which could lead to residual astigmatism.[6] In addition, the likelihood of postoperative complications, such as rotation, can vary depending on the adhesive properties of the posterior capsule with different IOL materials.[6]

According to the literature, IOL rotation primarily occurs during the early postoperative period, typically within the first 24 hours. Therefore, close monitoring during the initial follow-up visits is essential, including an examination under mydriasis to assess the position of the lens markings.

Regarding the effect of a toric lens axis shift on refraction, Novis estimated for toric monofocal lenses that approximately 1 degree of deviation results in a 3.3% loss of the cylinder's effective power, although no specific reference was made to multifocal toric lenses.[7] Consequently, if the lens rotates more than 30 degrees, it will introduce additional astigmatism into the optical system. Moreover, the

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effect of axis shift and the associated loss in cylinder power become more pronounced with higher cylindrical power.[8] In addition, the residual refractive error will not be purely astigmatism but will also include a degree of hyperopia, which increases as the lens axis deviates further from its correct position.[9] Garzón et al. showed that toric lens misalignment has slightly more impact on visual acuity after multifocal than monofocal toric IOL implantation.[10]

However, toric lens misalignment not only results in residual astigmatism but also decreases visual quality and modulation transfer function (MTF), with even a 5 degrees rotation or tilt causing a significant reduction in MTF.[11–15] In addition to vision loss due to refractive errors associated with lens rotation and reduced optical quality, the patient may also experience halos or dysphotopsia. This highlights the importance of correctly aligning the lens on the intended axis and minimizing factors that could lead to rotation, which could negatively affect patient satisfaction.

The Clareon PanOptix Toric IOL (Alcon Laboratories, Inc.) is a new trifocal toric lens that combines the optical design of the AcrySof IQ PanOptix Toric (Alcon Laboratories, Inc.) with the Clareon material. As previously mentioned, the material of the lens can influence its rotational stability. Although the AcrySof IQ PanOptix Toric has demonstrated good rotational stability, the fact that the Clareon PanOptix Toric IOL is made from a different material suggests that an analysis of its rotational stability is necessary to confirm similar performance.[16] Therefore, the aim of this study was to evaluate the rotational stability, centration, visual outcomes, and patient satisfaction provided by the Clareon PanOptix Toric IOL during the first 3 months after implantation.

METHODS

This prospective, single-center, observational, noncomparative study was conducted at San Carlos Hospital in Madrid, Spain. The study was reviewed and approved by the hospital's Ethics Committee (Code 22/405-O_P). Written informed consent was obtained from all patients preoperatively, after they were fully informed about the purpose of the study. The study adhered to the tenets of the Declaration of Helsinki.

The inclusion criteria for this study were as follows: patients aged 50 years or older with age-related cataracts and no comorbidities; regular corneal astigmatism greater than 1.50 diopters as measured by an automatic keratometer, with regularity confirmed by topography; spherical IOL power between +15.00 diopters (D) and +25.00 D; a desire for spectacle independence after surgery, accompanied by realistic expectations; and availability, willingness, and cognitive awareness sufficient to comply with examination procedures. Exclusion criteria included unrealistic expectations, irregular astigmatism, and any difficulty with patient cooperation, such as living far from the hospital or having general health conditions. Patients with acute or chronic conditions that could increase risk or confound study results (eg, diabetes mellitus with retinopathy, immunocompromised status, and glaucoma) were also excluded. Additional exclusion criteria included any ocular comorbidity, a history of ocular trauma or prior ocular surgery, including refractive procedures, as well as capsule or zonular abnormalities that might affect postoperative lens centration or tilt (eg, pseudoexfoliation syndrome, chronic uveitis, and Marfan syndrome). Patients with pupil abnormalities, such as nonreactive, tonic, or abnormally shaped pupils, or pupils that do not dilate under mesopic or scotopic conditions, were also excluded.

Preoperative and Postoperative Assessments

Preoperative assessments included refraction, slitlamp examination, fundus examination, biometry, posterior segment optical coherence tomography, and corneal topography. IOL power was calculated using the Barrett Toric formula, with emmetropia as the target refraction for both eyes.

Refraction and visual acuity (VA) at far (4 m), intermediate (60 cm), and near (40 cm) distances were assessed at the 1-month and 3-month visits under both monocular and binocular conditions. Visual acuity was measured using Early Treatment Diabetic Retinopathy Study charts with 100% contrast under photopic conditions at 4 m, and results were recorded in logMAR. For intermediate (DCIVA) and near visual acuities, corrected (DCIVA and DCNVA) measurements were performed monocularly and binocularly.[17]

IOL displacement and rotation were quantified aided by the PIOLET software (Position IntraOcular Lens Tracker), developed by the Electronics Department of the University of Alcalá (Madrid).[18]

As input data, PIOLET requires 2 digital images (ie, a reference image and a target image). Immediately after surgery, photographs were taken with a slitlamp using retroillumination and additional external lighting, so both the lens marks and the conjunctival vessels could be seen clearly and sharply (day 0). The slitlamp was positioned in the operating room, and the picture was taken before the patient was moved to the recovery room. This reference location was considered the "zero position," and the decentration and rotation data shown in the article are in fact position changes relative to that "zero position." During the postoperative follow-up visits, the pupil was dilated and the same procedure was repeated. The surgeries were performed early in the morning, and all subsequent visits, during which images were taken (on days 1, 7, 30, and 90), were also scheduled in the morning.

Patient satisfaction and spectacle independence were measured using the validated CatQuest-9SF questionnaire.

All surgical procedures were assisted by the Callisto Eye system (Carl Zeiss Meditec AG), which offers a range of functionalities beyond IOL alignment, including multifocal positioning, capsulorhexis sizing and placement, and guidance for incision location. IOL power was calculated using the Barrett Toric formula (lens factor +1.94; design factor +5.0) and the manufacturer's recommended A-constant of 119.10. The target refraction for both eyes was emmetropia, with the selected IOL power being the one that resulted in the refraction closest to zero.

Postoperative medication was prescribed according to the hospital protocol, including topical antibiotics and steroids.

Intraocular Lens

The Clareon PanOptix Toric IOL is a trifocal lens designed to provide vision at far, intermediate, and near distances while also offering various cylinder powers to correct preexisting corneal astigmatism. This IOL features a diffractive design with a negative spherical aberration of -0.1 μm on the anterior surface. It creates 3 effective focal points: 1 for distance, 1 for intermediate (60 cm/+2.17 D add), and 1 for near vision (40 cm/+3.25 D).[19] To address corneal astigmatism, the lens has a biconical posterior surface and can correct up to 3.75 D of astigmatism.

Clareon (Alcon Laboratories, Inc.) is a new cross-linked acrylic optic biomaterial developed by combining a hydrophilic polymer (2-hydroxyethyl-methacrylate) and a hydrophobic component (phenylethyl acrylate) with a chemically bonded ultraviolet absorber.[20] This material may improve clarity and reduce surface haze, roughness, and glistenings compared with Acrysof (Alcon Laboratories, Inc.).[21]

Statistical Analysis

The sample size was calculated based on the primary endpoint (rotation) using as reference data published by Ribeiro et al. for the AcrySof IQ PanOptix toric IOL.[16] With an α risk of 0.05 and a β risk of 0.2 in a 2-sided test, 44 participants (44 eyes for monocular tests, including rotation, and 88 eyes for binocular tests) were needed to detect a statistically significant difference of 1 degree or more. The SD was assumed to be 2.15. A dropout rate of 20% was anticipated because of the high number of visits required, each involving pupil dilation and photography, which may lead some patients to discontinue their participation.

All study data were recorded in an Excel database (Microsoft Office 2010, Microsoft Corp.). Statistical analysis was conducted using IBM SPSS Statistics (v. 22.0, IBM Corp.).

A descriptive statistical analysis was performed, including the mean and SD for each parameter evaluated in the study.

Normality of data samples was assessed using the Shapiro-Wilk test. The *t* test was used to compare data between visits, while the Mann-Whitney *U* test was applied to variables that were not normally distributed. A *P* value of less than 0.05 was considered statistically significant for all tests.

Only the right eye of each patient was included in the analysis of rotation, decentration, refraction, and monocular visual acuity.

RESULTS

A total of 80 eyes from 40 patients were included in this study. The mean preoperative characteristics are detailed in Table 1. The biometric data provided correspond to the right eye of each patient.

Table 1. Preoperative characteristics of patients

Parameter	Mean ± SD (range)
Age (y)	74.0 ± 8.2 (54, 87)
Sex (F/M)	80%/20%
SEQ (D)	−0.39 ± 2.33 (−7.50, +3.88)
IOL power (D)	20.80 ± 2.29 (16.00, 25.00)
Mean corneal astigmatism (D)	2.21 ± 0.70 (1.50, 4.19)
AL (mm)	23.57 ± 0.91 (22.14, 25.70)
	<23.00 (14 eyes)
	23.01, 25.00 (22 eyes)
	>25.00 (4 eyes)
ACD (mm)	3.08 ± 0.37 (2.26, 4.05)
IOP (mm Hg)	14.25 ± 2.80 (10.0, 22.0)
Photopic pupil size (mm)	3.04 ± 0.62 (1.60.0, 4.96)
Spherical IOL power (D)	20.80 ± 2.29 (16.00, 25.00)
Cylinder IOL power (D)	2.71 ± 0.81 (1.00, 3.75)
Distribution of cylindrical IOL powers	1.00 D (2.5%)
	1.50 D (17.5%)
	2.25 D (20%)
	3.00 D (37.5%)
	3.75 D (22.5%)

ACD = anterior chamber depth; AL = axial length; SEQ = spherical equivalent
The biometric data presented correspond to the right eye of each patient.

Rotation and Decentration

Displacement (along the *x* and *y* axes) and rotational stability were assessed for all IOLs implanted in the right eye. Baseline (reference) data were obtained from images recorded immediately after IOL implantation. The results are summarized in Table 2. This table includes both actual values (*r*), which represent the directly measured values, and absolute values (abs), where the sign of the measurement has not been considered.

Considering the absolute values, the mean IOL rotation 24 hours postoperatively was 0.95 ± 1.82 degrees (range 0.00 to 5.27 degrees) relative to the implantation axis. Minimal variations were observed throughout the postoperative period, with a final rotation of 1.04 ± 0.97 degrees at 3 months. Actual measurements, not accounting for absolute values, ranged from 2.90 degrees counterclockwise to 5.57 degrees clockwise at the 3-month visit. There were no statistically significant differences between the values obtained at 24 hours and those at 3 months, whether analyzing absolute values (*P* = .221) or actual values (*P* = .179). At the 3-month follow-up, a patient (2.5%) had a rotation greater than 5 degrees in the right eye (5.57 degrees) and 2 patients (5%) in their left eye (5.2 degrees and 8 degrees).

At the 24-hour postoperative evaluation, the mean displacement in absolute terms was 0.14 ± 0.18 mm (range 0.00 to 0.76 mm) along the *x* axis and 0.16 ± 0.20 mm (range 0.00 to 0.82 mm) along the *y* axis. Subsequent postoperative evaluations revealed no clinically significant changes, with measurements at 3 months remaining very close to those obtained 24 hours after implantation, resulting in final values of 0.19 ± 0.36 mm along the *x* axis and 0.19 ± 0.25 mm along the *y* axis.

When comparing the results between 24 hours and 3 months, the *P* value was 0.007 for the *x* axis when analyzing absolute values and 0.002 when analyzing actual values. For the *y* axis, the *P* value was 0.013 for both absolute and actual values.

Table 2. Rotation and decentration mean values, SD, and range, measured at 1 day and 7 days and 1 month and 3 months postoperatively

Parameter	1 d	1 wk	1 mo	3 mo
Rotation (*r*), degrees	1.31 ± 2.34 (−3.44, 5.27)	1.19 ± 1.62 (−2.28, 5.56)	1.19 ± 1.07 (−2.14, 5.05)	1.08 ± 1.77 (−2.90, 5.57)
Rotation (abs), degrees	0.95 ± 1.82 (0.00, 5.27)	1.05 ± 1.13 (0.03, 6.56)	0.98 ± 0.65 (0.00, 6.05)	1.04 ± 0.97 (0.12, 5.57)
Dx (*r*), mm	0.08 ± 0.22 (−0.36, 0.76)	0.12 ± 0.18 (0.00, 0.85)	0.18 ± 0.30 (0.00, 0.92)	0.19 ± 0.36 (0.00, 0.90)
Dx (abs), mm	0.14 ± 0.18 (0.00, 0.76)	0.12 ± 0.18 (0.00, 0.85)	0.18 ± 0.30 (0.00, 0.92)	0.19 ± 0.36 (0.00, 0.90)
Dy (*r*), mm	0.16 ± 0.20 (0.00, 0.82)	0.19 ± 0.24 (0.00, 0.88)	0.21 ± 0.26 (−0.01, 0.89)	0.19 ± 0.25 (0.01, 0.88)
Dy (abs), mm	0.16 ± 0.20 (0.00, 0.82)	0.19 ± 0.24 (0.00, 0.88)	0.21 ± 0.26 (0.00, 0.89)	0.19 ± 0.25 (0.01, 0.88)

Dx = lateral decentration in the *x* direction; Dy = lateral decentration in the *y* direction
Actual values (*r*) represent the directly measured values, whereas in absolute values (abs), the measurement's plus-or-minus sign has not been taken into account

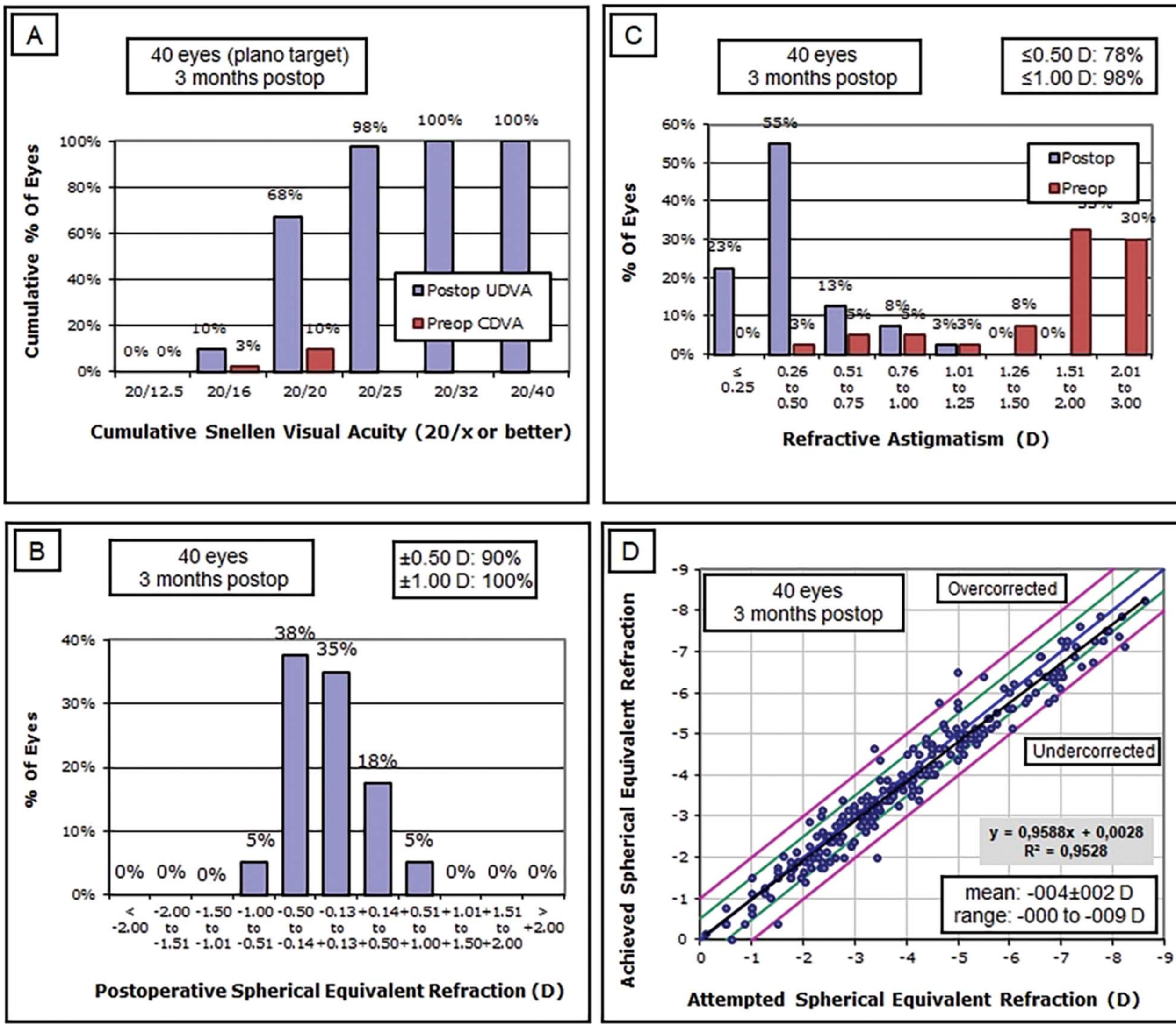

Figure 1. Standard graphs for reporting refractive outcomes after IOL implantation (40 right eyes, 3 months postoperatively). *A*: Cumulative distribution of monocular UDVA and CDVA. *B*: Distribution of postoperative SEQ refraction. *C*: Distribution of postoperative refractive astigmatism. *D*: Attempted vs achieved SEQ of manifest refraction. SEQ = spherical equivalent

Refraction and Visual Acuity

The mean postoperative spherical equivalent (SEQ) was −0.15 ± 0.31 D (range −0.88 D to 0.63 D) at 1 month and −0.09 ± 0.35 D (range −0.75 D to 0.75 D) at 3 months (*P* = .096). As shown in Figure 1B, the SEQ distribution at 3 months revealed that 90.0% of eyes were within ±0.50 D and 100% were within ±1.00 D of emmetropia. Postoperative astigmatism measured was −0.58 ± 0.31 D (range −1.75 D to 0.00 D) at 1 month and −0.52 ± 0.28 D (range −1.25 D to 0.00 D) at 3 months. Figure 1C illustrates that at 3 months, 78.0% of eyes had astigmatism within ±0.50 D and 98.0% within ±1.00 D of the target. Only 1 patient had astigmatism greater than 1.00 D (1.25 D at 3 months, compared with 1.75 D at 1 month).

The mean visual acuity values for all distances at the 1- and 3-month follow-up are presented in Table 3. Figure 1A depicts the distribution of the difference between postoperative monocular uncorrected visual acuity (UDVA) at the 3-month visit and preoperative monocular corrected distance visual acuity (CDVA). At 3 months, the mean monocular UDVA was 0.07 ± 0.07 logMAR. At this time, 68% of right eyes achieved a UDVA of 0.0 logMAR or better, 98% achieved 0.1 logMAR or better, and 100% achieved 0.2 logMAR or better. The mean monocular DCIVA (at 60 cm) at 3 months was 0.10 ± 0.09 logMAR, while the binocular DCIVA was 0.07 ± 0.08 logMAR. The mean DCNVA (at 40 cm) was 0.13 ± 0.08 logMAR monocularly and 0.09 ± 0.07 logMAR binocularly.

When comparing visual acuities at 1 and 3 months, statistically significant differences were found in binocular CDVA for far vision (*P* = .007) and in intermediate visual acuity, both monocular (*P* = .015) and binocular (*P* = .024). Results were consistently better at 3 months.

Table 3. Average monocular and binocular UDVA, CDVA, DCIVA, and DCNVA measured at 1 month and 3 months postoperatively

Parameter	Month 1	Month 3	*P* value (1 mo vs 3 mo)
UDVA			
Monocular	0.07 ± 0.06 (−0.04, 0.26)	0.07 ± 0.07 (−0.10, 0.58)	0.073
CDVA			
Monocular	0.00 ± 0.05 (−0.12, 0.16)	0.00 ± 0.05 (−0.10, 0.08)	0.051
Binocular	−0.01 ± 0.04 (−0.10, 0.08)	−0.03 ± 0.05 (−0.12, 0.08)	**0.007**
DCIVA			
Monocular	0.13 ± 0.11 (0.00, 0.44)	0.10 ± 0.09 (−0.06, 0.28)	**0.015**
Binocular	0.09 ± 0.09 (−0.06, 0.36)	0.07 ± 0.08 (−0.08, 0.24)	**0.024**
DCNVA			
Monocular	0.13 ± 0.09 (0.04, 0.40)	0.13 ± 0.08 (0.04, 0.34)	0.151
Binocular	0.10 ± 0.07 (0.02, 0.28)	0.09 ± 0.07 (0.00, 0.28)	0.185

Statistically significant values between the 2 visits are highlighted in bold

Questionnaires

Figure 2 shows the results of the CatQuest-9SF questionnaire administered at 3 months. All patients (100%) reported that their vision did not cause any difficulty in their daily lives. Regarding satisfaction, 97% of patients indicated they were either very satisfied or fairly satisfied. For most everyday tasks—including recognizing faces, reading prices while shopping, walking on uneven ground, doing needlework and handicrafts, reading text on television, and engaging in a preferred hobby—the majority of patients (92% to 100%) reported no difficulty. However, 1 patient (3%) experienced significant difficulty reading newspaper text, and 3 patients (8%) had some difficulty reading subtitles on TV. No patients reported being very dissatisfied or experiencing severe difficulties with any of the tasks.

Adverse Events

Regarding adverse events, during the surgical procedure, 1 patient (P41) required sutures in both eyes, and 1 month postsurgery, 2 patients developed moderate keratitis. No further adverse events were reported throughout the study.

DISCUSSION

The material used in the manufacture of IOLs has been shown to influence the rotation of toric lenses.[6] Although Wu et al. reported that hydrophobic acrylic IOLs were the most stable, Lombardo et al. found that hydrophobic acrylic IOLs have the strongest adhesive properties, followed by hydrophilic acrylic, PMMA, and silicone IOLs.[6,22] In addition, Linnola et al. demonstrated that hydrophobic acrylic IOLs offer better rotational stability compared with silicone IOLs, and Draschl et al. found that hydrophobic acrylic IOLs outperform their hydrophilic counterparts.[23,24] For this reason, this study aims to evaluate the rotational stability of the PanOptix trifocal toric lens after the transition from the AcrySof material (AcrySof PanOptix Toric IOL) to the Clareon material (Clareon PanOptix Toric IOL). To the authors' knowledge, this is the first study focused on assessing the rotational performance of this new lens material in a diffractive design.

A recently published meta-analysis, which included 51 studies, indicates that most cases exhibit rotations of less than 5 degrees, with a pooled mean absolute rotation of 2.36 degrees for all toric IOLs.[25] Our findings are consistent with this, showing a mean rotation of less than 2 degrees from the time of implantation to 3 months postsurgery. Focusing on studies involving the PanOptix lens with the AcrySof material, the predecessor to Clareon, our results align with those of Ribeiro et al., who reported a mean rotation of 1.59 ± 2.15 degrees and Donmez et al., who reported 2.1 ±

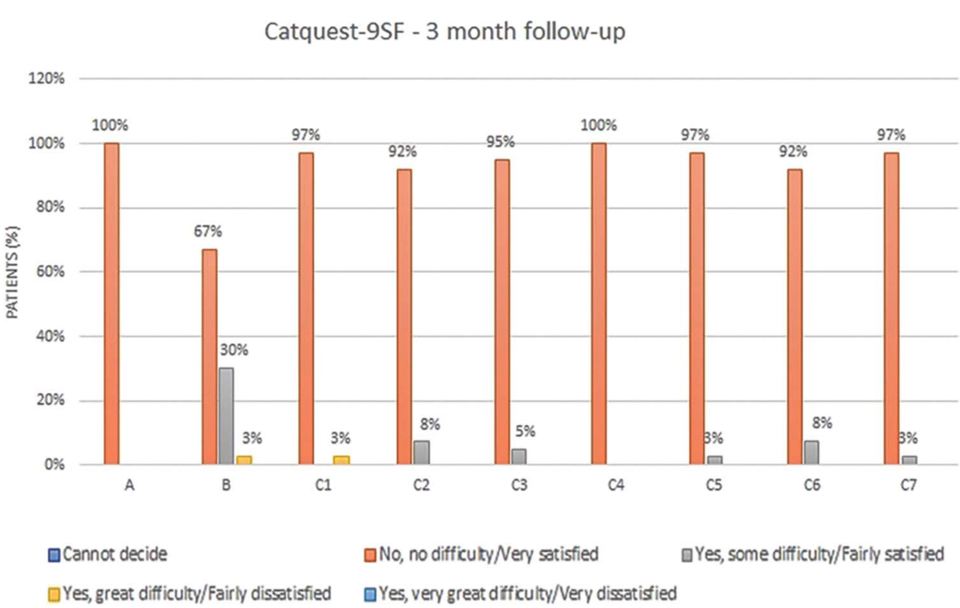

Figure 2. Results of the CatQuest-9SF questionnaire at the month 3 postoperative visit. A: Do you find that your sight at present causes you difficulty in your everyday life? B: Are you satisfied or dissatisfied with your sight at present? C1: Do you have difficulties with the following activities because of your sight? C2: Reading text in newspapers. C3: Recognizing faces of people you meet. C4: Seeing the process of goods when shopping. C5: Seeing to walk on uneven surfaces. C6: Seeing to do handicrafts, woodwork. C7: Reading subtitles on TV.

2.3 degrees, both at 3 months.[16,26] When compared with other toric trifocal lenses, our results are similar to those obtained with the POD FT model (Beaver-Visitec International), a lens featuring a double C-loop IOL with 5 degrees angulation made of 26% hydrophilic material (hydroxyethylmethylmethacrylate–co-methylmethacrylate copolymer), as reported by Poyales et al., who found a rotation of 1.65 ± 0.89 degrees, and by Ribeiro et al., who observed a rotation of 1.89 ± 3.31 degrees.[16,18] In the absence of studies evaluating toric trifocal rotation with the Clareon material, we compared published results with the toric monofocal lens, Clareon Toric IOL (Alcon Laboratories, Inc.), where Schartmüller et al. found a rotation at 6 months of 1.33 ± 1.99 degrees.[27]

Although rotation has been extensively studied, in vivo decentration has received much less attention for this type of lens. No studies have been found involving PanOptix lenses in any of the materials in which they are manufactured, but data are available for the POD FT model, which reported values of 0.14 ± 0.16 mm along the x axis and 0.16 ± 0.20 mm along the y axis at 3 months postoperatively.[18] Our decentration values are very similar to those reported for the POD FT model. In optical bench studies, Pan et al. and Can et al. observed that decentration of the AcrySof PanOptix IOL primarily affected the far MTF, with a noticeable decrease in this parameter for larger apertures (4.5 mm).[28,29] The Pan study investigated decentration starting at 0.3 mm, while the Can study began at 0.5 mm—significantly larger values than those observed in our study.

Regarding refractive outcomes, we found only 1 published study that reports results with the same lens used in our research, although their data covered only 1 month postsurgery.[30] Melendez et al. reported a mean absolute prediction error of 0.43 ± 0.36 D, which is slightly higher than what we observed, because our results were closer to emmetropia. In addition, the percentage of eyes with an absolute prediction error ≤ 0.5 D was higher in our study, with 90% of eyes falling within that range compared with 72.5% in the study of Melendez et al. Regarding monocular UDVA, 95% of eyes in the Melendez study achieved 20/25 or better, while in our study, this figure was 98%. Regarding DCIVA and DCNVA, their results were 0.18 ± 0.18 and 0.07 ± 0.17 logMAR, respectively, which are very similar to our findings at 1 month of 0.13 logMAR for both distances.[30]

The outcomes reported by Ribeiro et al. with the Acrysof Panoptix toric lens also align with our monocular results at 3 months, showing differences of no more than 4 letters across all distances.[16] Similarly, the Mohaseb study, which included binocular data from 35 patients, demonstrated comparable results, with differences of no more than 4 letters at all analyzed distances.[31]

Although our results regarding visual acuity show statistically significant differences between month 1 and month 3, these differences are clinically insignificant. In our experience, due to the alterations commonly observed in the tear film—particularly in elderly patients, and even more so in women—caused by eye exposure during surgery and the postoperative treatment in the weeks after the intervention, it is better to perform a definitive refraction at 3 months. This helps to avoid prescribing potential cylinders induced by astigmatism resulting from these tear film changes.

Regarding patient satisfaction, all participants reported that their vision did not cause any difficulties in their daily lives, which is particularly noteworthy given that the lens used was both trifocal and toric. In addition, 97% of patients indicated that they were either very satisfied or fairly satisfied. These results align with those reported by Rementería-Capelo and Galvis, although their studies involved the spherical trifocal model made from the Acrysof material.[32,33]

To evaluate how data that deviated further from the mean across the various measured parameters affected patients' vision or satisfaction, these cases were analyzed in detail. One patient (P03) exhibited a lens rotation of more than 5 degrees, in the left eye, by the end of the study. The implanted lens had an astigmatism of 3.75 D, resulting in a UDVA of 0.08 logMAR with a residual astigmatism of 0.50 D. Both CIVA and CNVA were 0.2 logMAR. Another patient (P15) showed significant lens decentration, with values around 0.8 mm along both the x and y axes. Her UDVA was 0.04 logMAR, while intermediate and near vision reached 0.08 logMAR in the right eye. The lens had a cylindrical power of 3.00 D. Finally, the patient who reported the lowest satisfaction on the questionnaire (P08) had a postoperative refractive error of +0.50 D in the right eye and −1.00 D of cylinder in the left eye, which contributed to his dissatisfaction. In this case, the lens implanted in the left eye was found to be rotated 8 degrees from the intended position. Given that the lens had a toricity of 2.25 D, according to Novis, this misalignment would result in a loss of effectiveness of approximately 26.4% or 0.6 D, which is slightly less than the observed residual refractive error.[7] The low incidence of visual difficulties reported by patients and their high satisfaction levels, as evidenced by the CatQuest-9SF questionnaire, further supports the clinical effectiveness and patient acceptance of this IOL.

This study has several limitations. First, although the sample size is representative, it is relatively small, which may affect the generalizability of the results to a broader and more diverse population, including patients with elongated eyes and large capsular bags. In addition, the lack of a comparative control group using other types of toric lenses restricts the ability to evaluate the Clareon PanOptix Toric's effectiveness relative to other available options. These limitations indicate that future research with larger sample sizes, extended follow-up periods, and direct comparisons would be valuable for confirming and expanding on our findings. In addition, other factors, such as the evaluation of dysphotopic phenomena associated with diffractive lenses and residual astigmatism, should be considered to further expand our understanding of this type of lens.

In conclusion, the Clareon PanOptix Toric IOL exhibits excellent rotational stability, minimal decentration, and effective astigmatism correction. The lens provides strong visual acuity outcomes and high patient satisfaction, making it a viable option for patients seeking spectacle independence despite significant astigmatism. The results are consistent with those achieved with its predecessor, the PanOptix lens made from the Acrysof material. Although the findings are promising, further research with larger sample sizes and extended follow-up periods is necessary to validate these results and to compare the Clareon PanOptix Toric with other toric IOL options to ensure comprehensive evaluation of its performance and patient outcomes.

WHAT WAS KNOWN

- The AcrySof IQ PanOptix Toric IOL has previously demonstrated reliable rotational stability in clinical outcomes.
- The material composition of IOLs has been shown to significantly influence the rotational behavior of toric lenses.

WHAT THIS PAPER ADDS

- The Clareon PanOptix Toric IOL demonstrated superior rotational stability, minimal decentration, and effective astigmatic correction, contributing to reliable postoperative outcomes.
- This IOL offers excellent visual acuity across multiple focal points and high levels of patient satisfaction, positioning it as a strong option for patients with significant astigmatism seeking reduced dependence on spectacles.

REFERENCES

1. Visser N, Bauer NJC, Nuijts RM. Toric intraocular lenses: historical overview, patient selection, IOL calculation, surgical techniques, clinical outcomes, and complications. J Cataract Refract Surg. 2013;39(4):624–637
2. Giers BC, Khoramnia R, Weber LF, Tandogan T, Auffarth GU. Rotation and decentration of an undersized plate-haptic trifocal toric intraocular lens in an eye with moderate myopia. J Cataract Refract Surg. 2016;42(3):489–493
3. Zhu X, He W, Zhang K, Lu Y. Factors influencing 1-year rotational stability of AcrySof Toric intraocular lenses. Br J Ophthalmol. 2016;100(2):263–268
4. Patnaik JL, Kahook MY, Berdahl JP, Hardten DR, Wagner BD, Seibold LK, Kramer BA. Association between axial length and toric intraocular lens rotation according to an online toric back-calculator. Int J Ophthalmol. 2022;15(3):420–425
5. Ruhswurm I, Scholz U, Zehetmayer M, Hanselmayer G, Vass C, Skorpik C. Astigmatism correction with a foldable toric intraocular lens in cataract patients. J Cataract Refract Surg. 2000;26(7):1022–1027
6. Wu J, Yang C, Yin Y, Liu L, Wang H. Impact of material and lens design on repositioning surgery of toric intraocular lenses: a single-arm meta-analysis. J Ophthalmol. 2022;2022:6699596
7. Novis C. Astigmatism and toric intraocular lenses. Curr Opin Ophthalmol. 2000;11(1):47–50
8. Viestenz A, Seitz B, Langenbucher A. Evaluating the eye's rotational stability during standard photography: effect on determining the axial orientation of toric intraocular lenses. J Cataract Refract Surg. 2005;31(3):557–561
9. Jin H, Limberger IJ, Ehmer A, Guo H, Auffarth GU. Impact of axis misalignment of toric intraocular lenses on refractive outcomes after cataract surgery. J Cataract Refract Surg. 2010;36(12):2061–2072
10. Garzón N, Poyales F, de Zárate BO, Ruiz-García JL, Quiroga JA. Evaluation of rotation and visual outcomes after implantation of monofocal and multifocal toric intraocular lenses. J Refract Surg. 2015;31(2):90–97
11. Felipe A, Artigas JM, Díez-Ajenjo A, García-Domene C, Peris C. Modulation transfer function of a toric intraocular lens: evaluation of the changes produced by rotation and tilt. J Refract Surg. 2012;28(5):335–340
12. Hamdi IM. Visual and optical performance before and after rotation of a misaligned STAAR toric implantable collamer lens. J Refract Surg. 2009;25(10 suppl):S934–S938
13. Pérez-Vives C, Ferrer-Blasco T, Madrid-Costa D, García-Lázaro S, Montés-Micó R. Optical quality of aspheric toric intraocular lenses at different degrees of decentering. Graefes Arch Clin Exp Ophthalmol. 2014;252(6):969–975
14. Hayashi K, Manabe S, Yoshida M, Hayashi H. Effect of astigmatism on visual acuity in eyes with a diffractive multifocal intraocular lens. J Cataract Refract Surg. 2010;36(8):1323–1329
15. Felipe A, Artigas JM, Díez-Ajenjo A, García-Domene C, Alcocer P. Residual astigmatism produced by toric intraocular lens rotation. J Cataract Refract Surg. 2011;37(10):1895–1901
16. Ribeiro FJ, Ferreira TB. Comparison of visual and refractive outcomes of 2 trifocal intraocular lenses. J Cataract Refract Surg. 2020;46(5):694–699
17. Fernández J, Ribeiro FJ, Rodríguez-Vallejo M, Dupps WJ Jr., Werner L, Srinivasan S, Kohnen T. Standard for collecting and reporting outcomes of IOL-based refractive surgery: update for enhanced monofocal, EDOF, and multifocal IOLs. J Cataract Refract Surg. 2022;48(11):1235–1241
18. Poyales F, Garzón N, Pizarro D, Cobreces S, Hernández A. Stability and visual outcomes yielded by three intraocular trifocal lenses with same optical zone design but differing material or toricity. Eur J Ophthalmol. 2019;29(4):417–425
19. Kohnen T, Herzog M, Hemkeppler E, Schönbrunn S, De Lorenzo N, Petermann K, Böhm M. Visual performance of a quadrifocal (trifocal) intraocular lens following removal of the crystalline lens. Am J Ophthalmol. 2017;184:52–62
20. Maxwell A, Suryakumar R. Long-term effectiveness and safety of a three-piece acrylic hydrophobic intraocular lens modified with hydroxyethyl-methacrylate: an open-label, 3-year follow-up study. Clin Ophthalmol. 2018;12:2031–2037
21. Wang Q, Yildirim TM, Schickhardt SK, Łabuz G, Khoramnia R, Merz PR, Son HS, Munro DJ, Friedmann E, Auffarth GU. Quantification of the in vitro predisposition to glistening formation in one manufacturer's acrylic intraocular lenses made in different decades. Ophthalmol Ther. 2021;10(1):165–174
22. Lombardo M, Carbone G, Lombardo G, De Santo MP, Barberi R. Analysis of intraocular lens surface adhesiveness by atomic force microscopy. J Cataract Refract Surg. 2009;35(7):1266–1272
23. Linnola RJ, Sund M, Ylönen R, Pihlajaniemi T. Adhesion of soluble fibronectin, vitronectin, and collagen type IV to intraocular lens materials. J Cataract Refract Surg. 2003;29(1):146–152
24. Draschl P, Hirnschall N, Luft N, Schuschitz S, Wiesinger J, Rigal K, Findl O. Rotational stability of 2 intraocular lenses with an identical design and different materials. J Cataract Refract Surg. 2017;43:234–238
25. Li ES, Vanderford EK, Xu Y, Kang PC. Rotational stability of toric intraocular lenses by lens model and haptic design: systematic review and single-arm meta-analysis. J Cataract Refract Surg. 2024;50(9):976–984
26. Donmez O, Asena BS, Aydin Akova Y. Subjective and objective clinical outcomes of a new trifocal toric intraocular lens and effect of femtosecond laser cataract surgery. Eur J Ophthalmol. 2022;32(4):2225–2233
27. Schartmüller D, Lisy M, Mahnert N, Schranz M, Danzinger V, Schwarzenbacher L, Pieh S, Abela-Formanek C, Leydolt C, Menapace R. Rotational stability and refractive outcomes of a new hydrophobic acrylic toric intraocular lens. Eye Vis (Lond). 2024;11(1):25
28. Pan RL, Tan QQ, Liao X, Xie LX, Qin SY, Tang YL, Lan CJ. Effect of decentration and tilt on the in vitro optical quality of monofocal and trifocal intraocular lenses. Graefes Arch Clin Exp Ophthalmol. 2024;262(10):3229–3242
29. Can E, Senel EC, Holmström STS, Piñero DP. Comparison of the optical behaviour of five different multifocal diffractive intraocular lenses in a model eye. Sci Rep. 2023;13(1):19646
30. Melendez RF, Nguyen TH, Solis AI, Ortiz D, Moezzi C, Hall B. Outcomes after implantation of a trifocal toric intraocular lens using intraoperative aberrometry, digital image tracking, and femtosecond laser. Clin Ophthalmol. 2024;18:2033–2039
31. Mohaseb K, Tischler A, Hall B, Isbister C, Godinho D, Goldberg A, Fine D. Refractive outcomes following bilateral implantation of a diffractive toric intraocular lens in a multisurgeon hospital setting. Can J Ophthalmol. 2024;59(1):e1–e6
32. Rementería-Capelo LA, García-Pérez JL, Gros-Otero J, Carrillo V, Pérez-Lanzac J, Contreras I. Real-world evaluation of visual results and patient satisfaction for extended range of focus intraocular lenses compared to trifocal lenses. Int Ophthalmol. 2021;41(1):163–172
33. Galvis V, Escaf LC, Escaf LJ, Tello A, Rodríguez LD, Lapid-Gortzak R, Carreño NI, Berrospi RD, Niño CA, Viberg A, Camacho PA. Visual and satisfaction results with implantation of the trifocal Panoptix intraocular lens in cataract surgery. J Optom. 2022;15(3):219–227

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