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ORIGINAL ARTICLE

EVALUATION OF POSTURE-RELATED CYCLOTORSION DURING CATARACT SURGERY WITH THE VERION IMAGE-GUIDED SYSTEM

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Purpose: To assess posture-induced ocular cyclotorsion in eyes undergoing conventional cataract surgery (CCS) with intraocular lens (IOL) implantation using the VERION Image-Guided System (Alcon).

Methods: Patients with cataracts scheduled for conventional phacoemulsification with IOL implantation were consecutively examined and recruited into the study. All cataract surgeries were performed in December 2023 in the Department of Ophthalmology at the Military Institute of Aviation Medicine (Warsaw, Poland). The degree and direction of ocular cyclotorsion were recorded using the VERION Image-Guided System by comparing preoperative images of the anterior segment of the eye, captured with the patient seated, with intraoperative images obtained in the supine position. In addition, the correlation between axial length (AL) and ocular cyclotorsion was analyzed.

Results: The study included 31 eyes of 31 patients (20 women and 11 men). The mean age was 71.35 ± 8.48 years (range, 49–90 years), and the mean AL was 23.59 ± 1.59 mm (range, 20.44–29.22 mm). The mean absolute value of ocular cyclotorsion was 4.26 ± 3.04° (range, 0–11°; median, 4°). Clockwise rotation occurred more frequently (61.29%; 19 eyes) than counterclockwise rotation (35.48%; 11 eyes). Incyclorotation (54.84%) was more common than excyclorotation (41.94%). There was no significant correlation between AL and the degree of ocular cyclotorsion, Spearman's rank correlation coefficient was ρ=0,14.

Conclusions: Posture-related cyclotorsion commonly occurs during CCS and may influence the accuracy of astigmatism correction by affecting the alignment of toric IOLs. The VERION Image-Guided System enables precise assessment and compensation of ocular cyclotorsion during cataract surgery.

Keywords: ocular cyclotorsion, cataract surgery, astigmatism correction

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INTRODUCTION

Ocular cyclotorsion is a physiological phenomenon characterized by rotational movement of the eye around the visual axis. This rotation occurs during the transition from a seated to a supine position and is primarily regulated by the vestibular system [1]. Cyclotorsional movements are essential for maintaining stable, clear, and single binocular vision during changes in head position [3].

When cataract surgery is performed in patients with coexisting astigmatism, it is essential to recognize that preoperative measurements and diagnostic tests are obtained with the patient in an upright position, whereas cataract surgery is performed with the patient in a supine position. Accurate correction of astigmatism during surgery requires proper alignment of the toric intraocular lens (toric IOL) along the intended axis. However, posture-induced ocular cyclotorsion is a major cause of toric IOL misalignment. Previous studies have shown that for every 1° deviation of the toric IOL from the intended axis, there is an approximate 3.3% loss of cylindrical correction [2,9]. Therefore, meticulous consideration of posture-related cyclotorsion is crucial to ensure proper toric IOL placement, minimize postoperative refractive errors, and achieve optimal visual outcomes.

Currently, eye-tracking systems are considered among the most promising technologies for compensating for posture-induced cyclotorsion during ophthalmic surgical procedures. One such device is the VERION Image-Guided (IG) System (Alcon Laboratories, Fort Worth, TX, USA), which enables real-time assessment and compensation of ocular cyclotorsion. The system employs a digital marker that captures an intraoperative image of the anterior segment of the eye and aligns it with a reference image acquired preoperatively while the patient is seated. Consequently, posture-induced cyclotorsion can be accurately corrected, ensuring precise alignment of the toric IOL.

Many studies have assessed cyclotorsion during various corneal refractive procedures [6,10]; however, the evaluation of posture-related cyclotorsion using an ocular registration system during conventional cataract surgery (CCS) remains insufficiently explored [5,12,13].

Therefore, the aim of this study was to measure both the degree and direction of posture-induced ocular cyclorotation during CCS. Furthermore, the stability of cyclotorsion throughout the procedure was evaluated, and the correlation between axial length (AL) and the amount of cyclorotation was analyzed.

METHODS

Participants

Patients with cataracts were consecutively screened and underwent a comprehensive ophthalmic examination, including a review of their medical history and axial length (AL) measurement using an optical biometer (ARGOS; Alcon Laboratories, Fort Worth, TX, USA). Patients diagnosed with visually significant cataracts were scheduled for conventional phacoemulsification with intraocular lens (IOL) implantation and recruited into this prospective observational study.

Patients with a history of intraocular surgery or trauma in the operative eye, pseudoexfoliation syndrome, crystalline lens subluxation, corneal edema, pterygium, or uveitis were excluded. All participants provided informed consent to participate in accordance with institutional guidelines and the tenets of the Declaration of Helsinki.

All cataract surgeries were performed in December 2023 in the Department of Ophthalmology at the Military Institute of Aviation Medicine (Warsaw, Poland).

Measurement of cyclotorsion

Posture-related cyclotorsion during phacoemulsification was measured using the VERION IG System. Before surgery, scans of the anterior segment of the eye were acquired in the seated position using the reference unit of the VERION IG System. Subsequently, during cataract surgery, cyclotorsion was measured in the supine position at four time points: before corneal incisions, before capsulorhexis, before IOL implantation, and after wound hydration. The IG System computed the direction and degree of cyclotorsion by synchronizing and comparing images of the same eye obtained preoperatively in the seated position with those captured intraoperatively in the supine position. The direction of cyclorotation was displayed as either clockwise (CW) or counterclockwise (CCW). Incyclotorsion and excyclotorsion were also recorded according to eye laterality. Additionally, the correlation between AL and ocular cyclotorsion was analyzed.

Because examination with the VERION IG System is noninvasive, approval from the Institutional Ethics Committee was not required for this study.

Statistical analyses

Statistical analyses were performed using Statistica version 13.3 (StatSoft Inc., Tulsa, OK, USA). The Shapiro–Wilk test was used to assess the normality of data distribution. Differences in the

mean absolute value of cyclotorsion across the various stages of cataract surgery were evaluated using Friedman repeated-measures analysis of variance (ANOVA) by ranks. Spearman's rank correlation analysis was applied to assess the strength of the relationship between two variables. Statistical significance was set at $p < 0.05$.

RESULTS

The study included 31 eyes (16 right and 15 left) from 31 patients (20 women and 11 men). The mean age of the participants was 71.35 ± 8.48 years (range, 49–90 years), and the mean AL was 23.59 ± 1.59 mm (range, 20.44–29.22 mm). The mean absolute value of ocular cyclotorsion was 4.26 ± 3.04° (range, 0–11°; median, 4°). In most eyes (67.74%; n = 21), cyclotorsion ranged between 1° and 5°. Cyclotorsion greater than 8° was observed in 5 eyes (16.13%). Figure 1 presents the distribution of the absolute values of cyclotorsion.

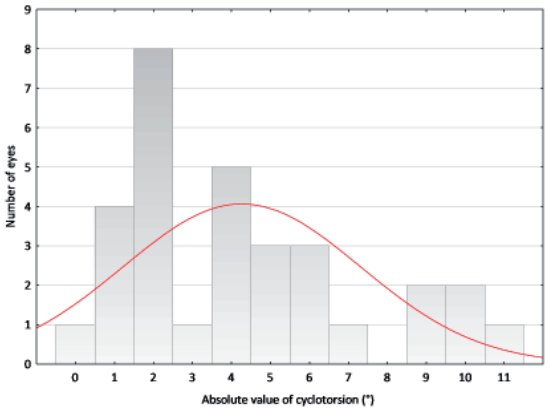

Fig. 1. Distribution of the absolute values of cyclotorsion.

Clockwise (CW) rotation (61.29%; n = 19) occurred more frequently than counterclockwise (CCW) rotation (35.48%; n = 11), while no cyclotorsion was observed in one eye (3.23%). Incyclotorsion was detected in 17 eyes (54.84%; 11 right and 6 left), and excyclotorsion in 13 eyes (41.94%; 4 right and 9 left). The mean absolute value of cyclotorsion did not change significantly at different stages of cataract surgery ($\chi^2(3) = 2.42$, $p = 0.49$; Table 1). Moreover, no significant correlation was found between axial length and the absolute value of cyclotorsion; Spearman's rank correlation coefficient was $\rho=0.14$.

DISCUSSION

Accurate correction of astigmatism during cataract surgery is closely associated with proper compensation for posture-induced cyclotorsion. Therefore, before cataract surgery, many surgeons mark the axis of astigmatism on the corneal limbus using a marking pen under topical anesthesia. However, this conventional manual marking method may be imprecise and can contribute to residual astigmatism, which remains a major factor impairing visual acuity after cataract surgery [7].

The use of image-guided systems may improve the precision of astigmatic axis marking, which is essential for adequate compensation of cyclotorsion and optimal positioning of the toric IOL. He et al. reported that corneal surgically induced astigmatism (SIA) was significantly lower when the VERION IG System was used during cataract surgery compared with manual axis marking [4].

Previous studies have shown that the transition from a seated to a supine position induces clinically significant ocular cyclorotation during cataract surgery [5,8,12,13] (Table 2).

In the present study, the mean absolute value of ocular cyclotorsion was 4.26 ± 3.04°, and the maximum cyclorotation reached 11°, which could result in more than 36% under-correction of astigmatism. Our findings are consistent with those reported by Terauchi et al., who also measured cyclorotation during CCS [13].

Regarding the direction of ocular cyclotorsion, we observed clockwise (CW) rotation more frequently than counterclockwise (CCW) rotation (61.29% vs. 35.48%). Furthermore, incyclotorsion occurred slightly more often than excyclotorsion. Similar findings have been reported in previous studies [5,12]. However, the current literature also indicates that the direction of cyclotorsion remains inconsistent. Some authors observed predominant

Tab. 1. Mean absolute value of cyclotorsion at various stages of cataract surgery.

Stage of surgery	Mean absolute value of cyclotorsion ± SD (°)	Median	IQR
Before corneal incisions	4.26 ± 3.04	4.00	4.00
Before capsulorhexis	4.58 ± 4.01	4.00	5.00
Before IOL implantation	4.81 ± 3.33	4.00	5.00
After wound hydration	4.42 ± 3.42	3.00	6.00

IOL – intraocular lens; SD – standard deviation; IQR – interquartile range

Tab. 2. Studies on posture-related ocular cyclotorsion during cataract surgery using ocular registration systems.

Study	Participants (n)	Eyes (n)	Mean age ± (years)	Mean absolute value of cyclotorsion (°)	Surgical procedure
Hummel et al. [5]	241	337	68.0 ± 9.0	5.81 ± 4.20	FLACS
Xiang et al. [14]	45	50	59.20 ± 13.56	8.03 ± 4.48	FLACS
Terauchi et al. [13]	93	107	71.7 ± 10.6	4.05 ± 2.82	CCS
Srujana et al. [12]	30	44	56.5 ± 17.1	5.84 ± 3.25	CCS, FLACS
Present study	31	31	71.35 ± 8.48	4.26 ± 3.04	CCS

FLACS – femtosecond laser-assisted cataract surgery; CCS – conventional cataract surgery

excyclorotation in the right eye and predominant incyclorotation in the left eye [13,15], whereas other researchers reported incyclorotation as the predominant direction in both eyes [5]. Zhao et al. suggested that the direction of cyclotorsion is not fixed and may depend on multiple factors that have not yet been fully explored [15]. Additionally, head tilt may cause discrepancies and measurement errors when cyclotorsion is assessed during surgery [10].

Axial length has been investigated as a potential factor influencing cyclotorsion in several previous studies [13–15]. In the present study, we found no significant correlation between axial length and the absolute value of cyclotorsion. Our findings are consistent with those reported by Terauchi et al. [13].

Furthermore, other factors such as sex, degree of astigmatism, and preoperative best-corrected visual acuity (BCVA) have also been explored in the aforementioned studies as possible factors influencing ocular cyclorotation [13–15]. Terauchi et al. reported that the mean absolute value of cyclotorsion was significantly greater in women than in men [13]. They suggested that this difference might be related to extraocular muscle volume, which tends to decline with age in women but remains relatively stable in men [11,13]. In contrast, neither the degree of astigmatism nor preoperative BCVA showed no significant association with the amount of cyclotorsion [13,15].

For surgeons performing cataract surgery, it is also essential to determine whether cyclotorsion remains stable throughout the procedure. Any change in cyclorotation during surgery may result in suboptimal positioning of the toric IOL, residual astigmatism, and reduced postoperative uncorrected visual acuity. Therefore, in our study, we evaluated the stability of cyclotorsion at four key time points during cataract surgery. We observed that the degree of cyclorotation did not change significantly across different stages of cataract surgery, and our findings were consistent with those reported by Srujana et al. [12]. The main limitations of the present study are the relatively small sample size and the lack of an assessment of mean postoperative corneal astigmatism. In addition, the influence of other clinical factors should be further evaluated to improve our understanding and prediction of posture-related cyclotorsion during cataract surgery. Moreover, differences in cyclorotation between FLACS and CCS have not yet been thoroughly investigated. Further studies involving a more comprehensive evaluation of cyclorotation are therefore warranted. In conclusion, posture-related cyclotorsion commonly occurs during conventional cataract surgery. Compensation for ocular cyclorotation is crucial for aligning the toric IOL along the correct axis to achieve optimal visual outcomes and reduce dependence on spectacles. The VERION Image-Guided System eliminates the need for preoperative manual marking of the astigmatic axis and enables accurate assessment and compensation of ocular cyclotorsion during cataract surgery.

AUTHORS' DECLARATION

Study Design: Ilona Kaczmarek, Grzegorz Rotuski, Joanna Dereń-Szumełda, Radosław Różycki. **Statistical analysis:** Ilona Kaczmarek. **Data Collection:** Ilona Kaczmarek. **Manuscript Preparation:** Ilona Kaczmarek. The Authors declare that there is no conflict of interest.

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