ARTICLE

Cyclorotation during femtosecond laser–assisted cataract surgery measured using iris registration

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Purpose: To assess ocular cyclorotation of eyes having femtosecond laser–assisted cataract surgery using iris registration.

Setting: Eye Institute of West Florida, Largo, Florida, USA.

Design: Retrospective cases series.

Methods: Charts of patients who had femtosecond laser–assisted cataract surgery with preoperative and intraoperative iris registration in 1 or 2 eyes between November 2015 and March 2016 were reviewed. Cyclorotation was assessed via iris-registration acquired preoperatively using the Cassini topographer (patient in upright position) and intraoperatively using the iris registration option of the Lensar laser system (patient in supine position) acquired immediately before the laser treatment.

Results: The study comprised 241 patients (337 eyes). The mean age of the 107 men and 134 women was 68.0 years ± 9.0 (SD) (range 37 to 90 years). The mean absolute value of cyclorotation was 5.81 ± 4.20 degrees (range 0 to 17 degrees), which was statistically significant when comparing the preoperative axis with the intraoperative axis deviation ($P < .0001$). Overall, incyclorotation (67.4%) was more common than excyclorotation (30.9%). In patients having bilateral femtosecond laser–assisted cataract surgery, bilateral incyclorotation (47.37%) was the most common occurrence.

Conclusions: During femtosecond laser–assisted cataract surgery, clinically significant cyclotorsion that might influence astigmatism correction outcomes can occur in patients having cataract extraction. Iris registration was useful in accounting for cyclorotation during this procedure when corneal or intraocular lens–based forms of astigmatic corrections will be used.

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Ocular cyclorotation and its implications during the correction of refractive errors, especially astigmatism, were initially encountered in corneal excimer laser refractive treatments; previous studies measuring cyclorotation during laser in situ keratomileusis (LASIK) and photorefractive keratectomy found a mean cyclorotation of 0.4 to 4.0 degrees.[1–5] At present, the development of femtosecond laser platforms and toric intraocular lenses (IOLs) offer both corneal (astigmatic keratotomies [AK] and limbal relaxing incisions [LRIs]) and IOL-based astigmatism correction during cataract surgery. This not only allows surgeons to remove a patient's cataract, it also gives them a means of decreasing or eliminating a patient's need for spectacle dependence. Achieving this goal also involves significantly reducing corneal astigmatic errors as well as spherical errors (myopia and hyperopia).

More than 50% of patients having cataract surgery have corneal astigmatism in the 0.5 diopters (D) to 1.5 D range.[6] To ensure full astigmatic correction, proper alignment in the axis of astigmatism for corneal-based and IOL-based approaches is essential. If not accounted for intraoperatively, cyclotorsion can cause rotational errors in this alignment and might lead to suboptimum correction of astigmatism. Ocular cyclorotation during femtosecond laser–assisted cataract surgery might be attributed to a combination of factors that could be categorized as (1) patient dependent: supine position during surgery, head position during surgery; (2) surgeon dependent: suboptimum preoperative axis marking, ocular position influenced by a surgeon's handling of the eye during femtosecond laser–assisted cataract surgery (patient interface using suction is maneuvered by surgeon); and (3) other extrinsic: free-floating surgical beds.

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This study assessed ocular cyclorotation in eyes having femtosecond laser–assisted cataract surgery using iris registration and the possible influence that cyclorotation might have on corneal- or lens-based astigmatism correction during cataract surgery.

PATIENTS AND METHODS

Patient Population

This was a single-center (Eye Institute of West Florida, Largo, Florida, USA) retrospective case series. The chart review included patients who had femtosecond laser–assisted cataract surgery with placement of a posterior chamber IOL between November 2015 and March 2016 using a femtosecond laser platform (Lensar) with Streamline 2 software (both Lensar, Inc.) and iris registration coupled with the Cassini topographer (iOptics Corp.).

All patients were informed of the risks and benefits before cataract surgery, and they gave their written informed consent in accordance with institutional guidelines. Institutional review board approval was obtained before the study was performed.

Inclusion and Exclusion Criteria

Patients were eligible for inclusion in the review if they were older than 18 years and had a diagnosis of 2+, 3+, and 4+ nuclear sclerotic, cortical, or posterior subcapsular cataract limiting vision. Patients were excluded if they had a history of pseudoexfoliation syndrome, corneal edema, Fuchs endothelial dystrophy, or previous surgery in the operative eye. Eyes that failed iris registration and had a cyclorotation above 17 degrees (the femtosecond laser platform's software is unable to measure cyclorotation above 17 degrees) were excluded from the study.

Image Acquisition and Docking Process

The Cassini topography platform combines light-emitting diode ray tracing and second Purkinje imaging technology, allowing for corneal astigmatism axis repeatability of 3 degrees. Furthermore, the topograper offers iris registration and allows for image acquisition to be coupled with the Lensar femtosecond laser platform on which astigmatism correction is based during cataract surgery. All patients in this study were evaluated preoperatively (seated upright position) using the Cassini topography platform. Then, the image was matched to the iris infrared image acquired via the Lensar femtosecond laser platforms using the Streamline 2 software (Figure 1). The Lensar image was acquired with the patient after the patient's eye was docked to the laser system. Docking was achieved using a plastic patient interface ring (centered around the corneal limbus) that is affixed to the eye using suction. A balanced salt solution was then placed in the patient interface and the laser was docked to the eye and locked into position. Incyclorotation and excyclorotation were measured, and their values were generated by the femtosecond laser platform's software. These values and the magnitude of the cyclorotation were generated by the laser and corrected for during corneal astigmatism correction. All femtosecond laser procedures were performed by 1 of 2 experienced surgeons (C.D.H., R.J.W.), each of whom performed more than 500 femtosecond laser cases before the case studies.

Statistical Analysis

Excel software (2007, Microsoft Corp.) and a custom Ophthalmic Data Analysis Software[A] were used for data collection and analysis. The cyclorotation data were tested to determine whether they followed a normal distribution according to the Shapiro-Wilks test with a P value less than 0.0001. An evaluation for power analysis was performed using post hoc power assessment. A P value less than 0.05 was considered statically significant.

Post hoc power analysis showed a power of 1 (100%); to test the null hypothesis that the mean value was not statistically different than the constant value of zero, a nonparametric test (Wilcoxon signed-rank test) was used.

RESULTS

The retrospective chart review identified 354 eyes of 253 patients who had femtosecond laser–assisted cataract surgery using the femtosecond laser platform. Of the 354 eyes, 3 eyes failed iris registration, and 14 eyes showed cyclorotation greater than 17 degrees for which the femtosecond laser platform could not measure total rotation with the current software. This resulted in 337 eyes of 241 patients (164 right eyes, 174 left eyes; 107 men and 134 women, aged 68.0 years ± 9.0 (SD) [range 37 to 90 years]) available for analysis. A further subanalysis of all patients receiving bilateral femtosecond laser treatment (190 eyes of 95 patients) was performed.

Of the 337 eyes that were analyzed, the mean absolute value of cyclorotation was 5.81 ± 4.20 degrees (range 0 to 17 degrees) (Table 1). Cyclorotation was statistically significant when comparing the preoperative axis with the intraoperative axis deviation ($P < .0001$). Overall, incyclorotation (227 eyes) was more common than excyclorotation (104 eyes) (Figure 2). In total, there were 8 eyes that did not show cyclorotation. In the right eyes, incyclorotation was significantly more common than excyclorotation. In the left eyes, incyclorotation was slightly more common than excyclorotation. The amount of cyclorotation was most commonly between 0 degree and 3 degrees (Figure 3). More than 39% of eyes (133/337) showed cyclorotation greater than 6 degrees (Figure 3).

A subanalysis of all patients having bilateral femtosecond laser–assisted cataract surgery (190 eyes of 95 patients) was performed to assess the congruency of cyclorotation between eyes. Bilateral incyclorotation was the most common occurrence (45 patients). Table 2 shows the results of the subanalysis.

DISCUSSION

Theoretic modeling indicates that residual astigmatism induced from axis error can be calculated via the formula $C = 2F \times \sin\alpha$, where C is residual astigmatism, F is the original astigmatic error, and α is the axis misalignment.[1] Using this equation, it can be calculated that a 10-degree error results in an approximately 34% decrease in astigmatic correction. Thus, iris registration and cyclotorsion correction has become the standard of care in modern refractive corneal surgery. It is reasonable to assume that cyclorotation also occurs during femtosecond laser–assisted cataract surgery AKs. In addition to cyclorotation induced purely by the patient lying supine as well as by the head positioning (as in refractive surgery), the manual handling of the patient interface applied during the docking of the femtosecond laser and other factors, such as the free-floating beds that some femtosecond lasers use, can induce cyclorotation. These factors might not be controlled during surgery, and a registration system that combines preoperative axis determination and intraoperative application of