Measurement of Cyclotorsional Displacement Using Iris Registration among Refractive Surgery Candidates with High Astigmatism

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Abstract

***Purpose*:** To determine cyclotorsional eye movement between the upright position and the supine position, in Iranian patients with high preoperative astigmatism

***Methods*:** This prospective cross sectional study contains 102 eyes of 59 patients who were candidates for refractive surgery with Technolas 217z100 excimer laser system for correction of high astigmatism. Wavefront measurements using Zywave II, Hartmann Shack aberrometer were performed in seated position. For all patients the amount of cyclotorsion before surgical procedure in supine position was measured by iris registration and the comparison between preoperative examinations in seated position with the supine position resulting in the amount of cyclotorsion was conducted by iris registration.

***Results*:** The mean cyclotorsion was found 3.18±2.37 (SD) degrees significantly greater than zero degrees (3.28±2.28 (SD) degrees in excyclotorsion and 3.01±2.54 (SD) degrees in incyclotorsion). Excyclotorsion was predominant trend of rotation in comparison with incyclotorsion in both right and left eyes. The amount of rotation greater than 2, 5 and 7 degrees occurred in 59.8%, 21.6% and 5.9% of the eyes, respectively.

***Conclusion*:** This study confirms significant rotational movement between the upright position and the supine position. Proper registration for appropriate correction of astigmatism and higher order aberrations (HAOs) for achieving optimal visual outcomes is recommended.

***Keywords*:** Cyclotorsion, Iris Registration, Keratorefractive Surgery

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Introduction

It has been shown in numerous studies that human eyes can undergo some motions including horizontal, vertical and rotational movements around their axis during daily activities.[1,2] Cyclotorsional movements of the eye can occur depending on the motion and orientation of the body so it can be changed while going from the vertical to the supine position. These rotations can be categorized in two groups: incyclotorsion which occurs when the eye has nasal rotation, and excyclotortion defined as outward rotation of eye so that the 12 o'clock position rotates temporally.[1]

Cyclotorsional movements are of great importance specially in refractive surgeries, since during examination, the patient is in the sitting position though he is in supine position while treating. Photoablation can cause such movements as well. If this ocular cyclotorsion is compensated for, it will have more reliable and effective surgical outcomes, specially in patients with higher preoperative astigmatism[3] and/or remarkable higher order aberrations (HAOs).[4] For example, 3 degrees rotation would lead to residual astigmatism that is 10% of the initial astigmatic power.[5] Available technologies can compensate for static as well as dynamic cyclotorsions. Some surgeons prevented cyclotorsional errors with traditional manual compensation techniques such as preoperative limbal marks aligned to the ocular reticule of the laser microscope, while modern technologies such as iris registration have been recently used to correct axis alignment for achieving optimum visual outcomes.[6] Using Iris Registration technology during operation can help the surgeon tracking cyclotorsional movements of the eye compensating for the rotations to ensure that the laser is always on target.

Although some studies found that most cyclotorsional errors in patients with refractive surgery are fewer than 2 degrees which does not cause noticeable effects on surgical outcomes, others report significant cyclotorsion errors range from 2 to 7 degrees that could introduce significant postsurgical aberrations.[6-8] In addition it is shown in some studies that application of iris registration in patients undergoing laser vision correction can help prevent residual astigmatism after surgery and better surgical outcome compared to traditional methods.[9] However some studies do not agree with this idea and represent ineffectiveness of this technology.[10]

This study was designed to suggest more evidences for necessity of intraoperative cyclotorsional monitoring in Iranian patients with moderate to high astigmatism due to higher risk of treatment problems in the context of cyclotorsional errors in this group of patients.[11] In the present study, we prospectively determined the rotational movement between the upright position and the supine position during photoablation in Iranian patients with high preoperative astigmatism.

Methods

This prospective cross sectional study was designed to evaluate the amount of cyclotorsion in Iranian patients who underwent refractive surgery for correction of high astigmatism at Farabi Hospital, Tehran University of Medical Sciences, Tehran, Iran, between January 2008 and February 2009.

Subjects

One-hundred and two eyes of 59 eligible patients included in the study receiving Photo Refractive Keratectomy with the Technolas 217z100 excimer laser system (Bausch & Lomb). All the subjects were operated by the same surgeon. The study size is estimated based on the prevalence of the significant cyclotorsion and previous similar studies performed. All patients were older than 20 years (range, 20 to 45 years). They had a refraction error stable for at least two years, the amount of refractive astigmatism more than 1 diopter (D), spherical equivalent refraction less than 10 D and the minimum level of central corneal thickness of at least 480 Micrometer. Also central keratometry was less than 48 D, with I-S less than 1.4 and best spectacle-corrected visual acuity (BSCVA) of more than $^{20}/_{25}$. All of patients who experienced previous refractive or cataract surgery were excluded from the study, other exclusion criteria were defined as irregular astigmatism, keratoconus, collagen vascular disease and retinopathy of diabetes.

Informed consent was taken by the patients and all principles of Helsinki accords were considered during the study. Also the study

was approved by Institutional Review Board of Tehran University of Medical Sciences.

Patient examination

All patients were asked to remove soft contact lenses and rigid gas permeable lenses for a minimum of four weeks before preoperative examination. Snellen E chart visual acuity test, manifest and cycloplegic refraction, slit-lamp microscopy, applanation tonometry, indirect ophthalmoscopy, corneal topography and wavefront measurements under mesopic condition (3 candelas/m^2) were done for all patients preoperatively. Pupil diameter was measured using wavefront sensor and all wavefront maps were standardized for pupil diameter of 6 mm. Corneal topography and wavefront measurements were performed in seated position using the Orbscan IIz (Bausch & Lomb, Surrey, United Kingdom) and Zywave II, Hartmann Shack aberrometer (Bausch & Lomb), respectively. For all patients the amount of cyclotorsion during the surgical procedure in supine position was measured by iris registration system of Zyoptix 217 Z100 excimer laser and the comparison between preoperative examinations in seated position with the supine position resulting in the amount of cyclotorsion was conducted by iris registration.

Torsion measurement

In order to provide the measures finding the amount of cyclotorsional movement during operation, we used iris registration system of Zyoptix 217 Z100 excimer laser and we derived the patients' spherical, cylindrical and axis error as well as preoperative spherical equivalent and pachymetry from the results based on the examination data. The diagnostic image was taken as a reference and compared with the image obtained before the surgery was started. Iris registration in sitting and supine position is performed and the difference between iris landmarks and crypts in these two positions were measured by a CCTV attached to the eye tracker. In our study the amount of cyclotorsion falls into three categories as incyclotorsion, excyclotorsion and a total amount provided by the result of iris registration.

Statistical analysis

To find out any significant torsion, the amount of cyclotorsion occurring during body position changes including incyclotorsion and excyclotorsion and the total amount was compared with zero using student *t*-test by SPSS version 20.[12] P-value less than 0.05 were considered as the statistically significant difference.

Results

We evaluated the amount of cyclotorsion during laser therapy in 102 eyes of 59 Iranian patients with the mean age of 27.7 years (range 20 to 45 years) among them 40.2% were male. Table 1 shows the ophthalmologic characteristics of the patients.

Table 2 shows the result of cyclotorsion with the change of position from seated to supine. The overall mean cyclotorsion was 3.18±2.37 (SD) degrees. *T*-test analysis results showed significantly greater cyclotorsion from zero. ($p<0.001$, 95% CI 2.71 to 3.64) specifically the amount of excyclotorsion was 3.28±2.28 (SD) degrees, significantly greater than zero degrees ($p<0.001$, 95% CI 2.71 to 3.84). Measurement of incyclotorsion showed 3.01±2.54 (SD) degrees of torsion significantly more than zero ($p<0.001$, 95% CI 2.16 to 3.86). In our study excyclotorsion was predominant trend of rotation in comparison with incyclotorsion in both right and left eyes. Excyclotorsion occurred in 65 eyes (64%). Separately, it occurred in 31 right eyes (56%) and 34 left eyes (72%). The mean excyclotorsion in right and left eyes were 3.18±2.30 (SD) degrees and 3.36±2.28 (SD) degrees, respectively.

Figure 1 shows the distribution of excyclotorsion and incyclotorsion in right and left eyes. Thirty-one right eyes (30%) had excyclotorsion and 24 right eyes (23%) had incyclotorsion. In left eyes excyclotorsion and incyclotorsion occurred in 34 eyes (33%) and 13 eyes (13%), respectively.

The amount of rotation greater than 5 and 7 degrees occurred in 21.6% and 5.9% of all eyes, respectively, also 59.8% of all eyes rotated more than 2 degrees in this study.

Table 1. Patients' characteristics

Patients characteristics	Mean (SD)
Age	27.7 (20-45)
Spherical error	-1.59 (2.12)
Cylindrical error	-3.01 (1.08)
Axis error	76.6 (74.28)
Preoperative spherical equivalent	-3.09 (1.97)
Pachymetry	545.05 (33.63)

Table 2. Amount of cyclotorsion with the change of position from seated to supine position in patients with high astigmatism

	Incyclotorsion			Excyclotorsion			Total		
	% (N)	Mean±SD	Range	% (N)	Mean±SD	Range	% (N)	Mean±SD	Range
OD	23.53% (24)	3.34±2.76	(0.00, 8.40)	30.39% (31)	3.18±2.30	(0.00, 9.70)	53.92% (55)	3.15±2.42	(0.00, 9.70)
OS	12.74% (13)	2.43±1.96	(0.20, 7.60)	33.33% (34)	3.36±2.28	(0.60, 10.20)	46.07% (47)	3.14±2.21	(0.20, 10.20)
Total	36.27% (37)	3.01±2.54	(0.00, 8.40)	63.72% (65)	3.28±2.28	(0.00, 10.20)	100% (102)	3.18±2.37	(0.00, 10.20)

OD: Right eye
OS: Left eye

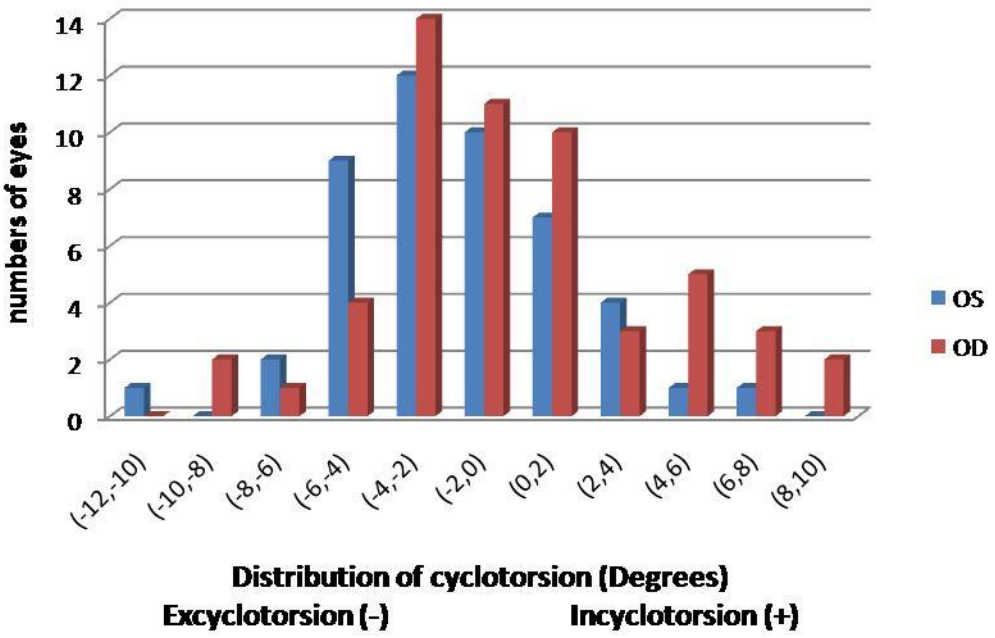

Figure 1. Distribution of excyclotorsion and incyclotorsion in right and left eyes

Discussion

In a wavefront-guided refractive surgery, it is needed to align the ablation exactly to the area estimated by the wavefront sensing device because wavefront is highly position-dependent.[13] Several studies have reported different degrees of ocular cyclotorsions occurring between wavefront measurement and the laser procedure, and demonstrated that rotation of 5 degrees or more can cause significant undercorrection of

the astigmatic component.[2,13] The previous reports have a range as wide as 0 to 16 degrees for cyclotosion.[14,15] Kim et al[7] and Park et al[13] found the amount of cyclotorsion close to 2.5 degrees. Arba-Mosquera et al[16] reported 3.1 degrees of static cyclotorsion using "Schwind Amaris" system. Ciccio et al[17] reported a mean cyclotorsion of 4.05 degrees in 1,019 eyes undergoing wavefront-guided refractive surgery. Swami et al[18] and Moshirfar et al[10] also reported a mean degree of rotation close to 4 degrees of ocular cyclotorsion in patients before laser procedure and they demonstradted that a 4-degree misalignment would cause a 14% undercorrection of the range of astigmatism, while 6 and 16 degrees cause 20 and 50 percent undercorrection of astigmatism.[14]

The present study reports the amount of ocular distortion that occurred during photorefractive keratectomy in 102 eyes of 59 Iranian patients and showed a moderate amount of cyclotorsion in the majority of the eyes with the changing orientation from seated to supine state upholding the idea of effectiveness of iris registration as a method for eye movement compensation which is in accordance with some previously conducted studies.[19,20] Rotation of eyes greater than 5 degrees occurs for 11.5%, 13% and 29% in studies of Park et al,[13] Kim et al[7] and Fabbraro et al,[2] respectively. This value in our study was 21.6% totally. The predominant trend for cyclotorsion in this study was excyclotorsion and it was similar to the results of studies of Febbraro et al[2] and Ciccio et al.[17]

Conclusion

This study confirms the necessity of using proper registration for appropriate correction of astigmatism and HAOs for achieving optimal visual outcomes in refractive surgery candidates with significant amounts of astigmatism. However, we could not verify the effect of iris registration because our study did not include eyes treated without cyclotorsional compensation. In addition in this cross-sectional study conduction of a postoperation follow-up was not applicable, so a prospective clinical study will be the subject of our future studies.

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