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Effectiveness of Technolas torsional eye tracking system on visual outcomes after photorefractive keratectomy

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Abstract

***Purpose*:** To investigate the efficacy of Technolas 217Z eye tracking system (*torsional component*) in corneal surface irregularity and high order aberrations (HOAs) after photorefractive keratectomy

***Methods*:** Patients with compound myopic astigmatism among persons demanding refractive surgery in Khatam-al-Anbia Eye Hospital with the mean age of 29 years were enrolled in this double-blind randomized interventional study. The mean spherical equivalent (SE) of refractive error was −4.75 diopters(D) (range: −1.5 to −7.0), and the mean astigmatism was 3 D (range:1.0–4). Many studies were performed for each patient including: A complete eye examination, visual acuity and Monocular contrast sensitivity evaluation, and refraction. Corneal topography, Orbscan II, and wavefront aberrometry were conducted. One eye was randomly assigned for aspheric treatment and applying eye tracking system. The other eye was treated without torsional eye tracking system. The outcome measures were uncorrected visual acuity (UCVA), best corrected visual acuity (BCVA), contrast sensitivity, corneal irregularity index in 3 mm and 5 mm optical zones in Orbscan II, and mean total HOAs at the 6-monthvisit.

***Results*:** Fifty eyes of 25 patients were enrolled. Mean UCVA was improved significantly in both the study and control groups in the 6-month post-operative follow-up. There was no significant difference between the 2 groups in UCVA and BCVA ($P = 0.185$ and $P = 0.176$, respectively). Total HOAs increased in both groups after PRK. However, they were lower in eyes treated with the eye tracking system ($P < 0.001$). Corneal irregularity index in 3 mm and 5 mm central zones in Orbscan II was significantly lower in the study group ($P = 0.045$ and $P = 0.031$ respectively). Contrast sensitivity function was not different in the 2 groups ($P = 0.15$).

***Conclusion*:** Our study findings suggest that applying 'Technolas 217z' eye tracker system (Bausch and Lomb Advanced) results in a more regular anterior surface of cornea. Therefore, we recommend it for surface laser refractive surgery.

Keywords: Photorefractive keratectomy; Visual function; Dynamic correction

Introduction

Excimer laser refractive surgery is one of the most popular procedures in the field of ophthalmology in recent decades. New techniques and new systems are developing constantly in this surgery to promote visual outcomes because most patients are young individuals who expect excellent results to enjoy the best possible quality of vision. The patient's unavoidable eye micro-movements is one of the problems that affects the post-operative

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quality of vision because it causes glare or astigmatism despite precise pre-operative measurements.[1,2] Eye tracking systems have been developed to overcome this shortcoming; however, when we encounter patients with excessive eye movements, we still cannot be sure about the efficacy of these systems.

Dynamic registration can be achieved by engaging the laser radar eye tracker, which registers the wavefront determined laser shot pattern to its corresponding position on the cornea by overlaying the identification reticles. The first reticle is the limbus ring, which provides the xy alignment, and dynamically maintains that alignment throughout the tracking of the dilated pupil margin. The second reticle is the cyclorotation alignment, which is implemented by rotating the image of the limbus ring taken from the orientation marks recorded during the wavefront capture. They are overlapped with the actual ink marks that still remain on the eye.

In this way, true registration can be achieved dynamically, not only in XY orientation, but also statically with regard to cyclorotation. Registration and tracking based on iris detail will provide a alternative for dynamic capture of cyclorotation, as well. [3]

In order to understand the eye tracking systems, a number of terms need to be defined. These include sampling rate, latency, tracker type, and closed vs open loop tracking.

Sampling rate describes how often the tracker measures the eye's location. Tracking frequencies vary from 60 Hz, based on the frame rate of certain video camera trackers, up to 4000 Hz seen with laser-radar tracking.

Latency is the time required to determine the eye's location calculate the required response, and move the laser tracker mirrors to compensate for the new location.

Typical video camera eye tracking uses infrared light illumination of the iris against a dark pupil in most refractive surgical systems.[3,4]

In 1994, Molebny presented an eye tracker system for excimer laser. He claimed his system provided an accuracy of 0.1 mm in eyes with ±2 mm micromovements.[3] Although several other eye tracking systems have been introduced to improve the accuracy of laser beam centeration, there is still a need for proving their efficacy.

After reviewing several databases including Pubmed, Scopus, and Google Scholar, to our knowledge, there is no comparative study on 'Technolas 217z' eye tracker system (Bausch and Lomb Advanced). This system is a dynamic rotational program that tracks and simultaneously adjusts the ablation pattern accordingly during the entire procedure.

Methods

This was a double-blind randomized interventional study. Twenty-five patients with compound myopic astigmatism were enrolled. The mean age was 29 years old (range: 18−40). The mean spherical equivalent (SE) of refractive error was −4.75 diopters (D) (range: −1.5 to −7.0), and the mean astigmatism was 3 D (range: 1.0−4). Patients with relative or absolute contra indications of refractive surgery including corneal ecstatic disorders, corneal haze and scar, autoimmune disease, pregnancy, breast feeding, and moderate to severe dry eye were not enrolled. Exclusion criteria were: Best corrected visual acuity (BCVA) less than 10/10, more than 0.5 D inter-ocular refractive error disparity, unstable refractive error (>0.5 D change through the last year), high order aberrations (HOA) <0.2 and >0.5 μm root mean square (RMS), and inter-ocular disparity in HOAs more than 0.05 μm. Patients were excluded with central corneal thickness (CCT) <490 μm and predicted CCT <400 μm, also. Contact lens users were asked to cease wearing them from 1 month before imaging.

The study adhered to the tenets of the Declaration of Helsinki. The protocol was approved by the institutional review board and ethics committee of the Mashhad University of Medical Sciences and was designed and performed from June to January 2013 in Khatam-al-Anbia Eye Hospital.

A complete eye examination including uncorrected visual acuity (UCVA) and BCVA evaluation with Snellen chart, manifest, and cycloplegic refraction (Autokeratorefractometer TOPCON KR8800), contrast sensitivity assessment (CSV 1000, Haag-Streit, Harlow, UK), slit lamp examination, and applanation tonometry were performed. Corneal topography (TMS4, Tomey, USA), elevation-based corneal topography, Orbscan (Orbscan II Bausch & Lomb Germany), and wavefront aberrometry (Zywave II, Technolas, Bausch & Lomb Germany) were provided for each patient preoperatively. For the purpose of analysis, UCVA and BCVA were converted to a logarithm of minimum angle of resolution (logMAR).

Wavefront analysis was performed under mesopic conditions in the room light with a pupil diameter of approximately 6 mm. Total high order aberrations (3rd and 4th orders) were expressed as Zernike polynomial coefficient values and presented as RMS in micrometers.

Monocular contrast sensitivity evaluation was provided with best corrected distance vision. Correction spectacles without glare were put on for each patient. The standard 8-foot distance between the patient and chart was considered in all examinations. Contrast sensitivity values were presented in curves and then transformed into a logarithmic scale. Final analysis was based on area under log contrast sensitivity function (AULCSF).

One eye was randomly assigned for PRK with the eye tracker system 'on' and the other eye underwent laser ablation with torsional eye tracker 'off'. This allocation was not based on refraction, high order aberrations or eye dominancy. The ablation protocol was 'aspheric' in both eyes. The patients and the examiners were masked to know which eye would be in the study group.

Post-operative visits were scheduled on days 1, 3, and 7 and the first, 3rd and 6th months after surgery. The outcome measures were UCVA, BCVA, contrast sensitivity, corneal irregularity index in 3 mm and 5 mm optical zones in Orbscan II and mean total HOA at the 6th months visit.

Treatment protocol

All the surgeries were performed by two experienced surgeons (S.ZG & H.G) with Technolas 217z (Bausch & Lomb