Original Article

Visual Acuity and Prognosis among Hyperopic Patients Undergoing Photorefractive Keratectomy Using Allegretto EX500 Excimer Laser

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Abstract

Purpose: This study aims to investigate the visual acuity and prognosis after photorefractive keratectomy among hyperopic patients with and without astigmatism.
Patients and Methods: In this interventional case series study, 74 eyes from 42 hyperopia patients with and without astigmatism who underwent photorefractive keratectomy using Allegretto EX500 excimer laser at Torfeh and Negah Eye Hospitals from 2014 to 2018 were enrolled. Pre-and post-surgical visual examination findings, including uncorrected distance visual acuity, corrected distance visual acuity, manifest refraction, cyclorefraction, and slit lamp examinations to measure ocular pressure and the presence or absence of haze, were recorded.
Results: The mean age of participants was 34 ± 9 years, and 54.8 % were female. The preoperative mean uncorrected distance visual acuity was 0.55 ± 0.25 LogMAR, which significantly improved to 0.11 ± 0.14 at 6 months postoperatively ($P < 0.0001$). The predictive value for surgical outcomes at six months post-operation was 71.6 % within ± 0.5 diopter, 89.2 % within ± 1 diopter, and 97.3 % within ± 2 diopters. No eye lost corrected distance visual acuity of two lines or more, and only 16.6 % (12 eyes) experienced a one-line reduction in corrected distance visual acuity. No other notable complications occurred.
Conclusion: Photorefractive keratectomy using Allegretto EX500 excimer laser is an effective and safe method for correcting mild to moderate hyperopia with or without astigmatism.

Keywords: Photorefractive Keratectomy; Hyperopia; Astigmatism; Outcome.

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Introduction

Refractive errors are one of the most common causes of visual impairment in the world and the second most common cause of treatable blindness after cataracts.[1] Refractive eye defects include myopia, hyperopia, and astigmatism.[2] There are many different methods to treat refractive errors, including eyeglasses, contact lenses, intraocular lenses, and photoablation surgical techniques. [3-6] Corneal photoablation techniques are all based on the maximum photon absorption at 193 nm by the cornea [4]. This energy breaks down the carbon-carbon and carbon-nitrogen bonds in the collagen fibers of the corneal stroma, resulting in the removal of the stroma by this wavelength of light without damaging the cornea and adjacent tissues. LASIK surgery is one of the most common methods of refractive surgery, which is effective in treating mild, moderate, and severe degrees of myopia with or without astigmatism, as well as hyperopia with or without astigmatism. Photorefractive keratectomy (PRK) is another common treatment that is widely used today.

PRK can be used to treat mild to moderate myopia and, to some extent, mild to moderate hyperopia with and without astigmatism. Although the use of PRK results in increased visual recovery time compared to LASIK and is associated with greater discomfort during the recovery time, it does not involve flap complications and has less corneal biomechanical instability compared to LASIK [7-11].

Haze is a form of healing response that occurs after superficial corneal incisions. The development of haze is one of the side effects of PRK, which can occur following the repair of the epithelium and the anterior part of the stroma. This healing response is minimal in LASIK and rarely occurs due to ablation in deeper stromal layers. It should be noted that in hyperopic

PRK, the ablation is performed in the midperiphery of the cornea, resulting in haze frequently occurring in a circular fashion in the midperiphery, unlike myopic PRK, which causes haze in the central part of the cornea and has a lesser effect on patients' vision. Given the small percentage of Iranian patients with hyperopia and hyperopia astigmatism undergoing PRK surgery in Iran, few studies have been conducted on refractive regression and corneal haze among these patients [12-15]. In this study, we aim to investigate the visual acuity, haze, and prognosis after PRK among Iranian hyperopic patients with and without astigmatism.

Patients and Methods

This interventional case series study evaluated 74 eyes of 42 patients with hyperopia or hyperopia and astigmatism, with values of 0.5 diopters or more for hyperopia and astigmatism, who underwent photorefractive keratectomy (PRK) at Torfeh and Negah Eye Hospitals between 2014 and 2018.

Patients who did not return for postoperative follow-up examinations, those with a history of cataract surgery, glaucoma, significant cataracts, retinal diseases such as diabetic retinopathy and retinal vessel diseases, pregnant or lactating women, severe dry eye patients, patients with a history of corneal or ocular surgery, and those with keratoconus or any corneal anomaly were excluded from the study. The study was approved by the ethics committee of Shahid Beheshti University of Medical Sciences, Tehran, Iran, with approval number IR. SBMU. ORC. REC. 1398. 009, and all patients provided written consent before participating. All patients in this study

underwent surgery with the aim of achieving a complete correction of their refractive error based on the laser device's nomogram. Cycloplegic refraction values were used in all patients to prevent residual hyperopia.

Surgical Methods

Tetracaine 0.5 % (Sinadaro, Tehran, Iran) was applied five minutes before and immediately before surgery. The skin around the eyes was washed with iodine 0.5 %. The eyes were then rinsed with balanced salt solution (BBS), and alcohol 20 % was applied for 20 seconds to remove the epithelium. A 6.5 mm optical zone and 9 mm transition zone were chosen for all patients. The ablation was performed using the wavefront-optimized profile, which was performed at half the distance between the pupil center and the corneal reflex. Centration selection was based on the corneal reflex: if the angle of kappa was less than one millimeter, centration was based on the corneal reflex; if the angle of kappa was one millimeter or higher, centration was halfway between the pupil center and the corneal reflex. After the excimer laser ablation, a sponge coated with mitomycin C (MMC) at 0.02 % concentration was applied for at least 30 seconds and up to 60 seconds (10 seconds per corrected diopter), and then the eye was immediately washed with sufficient amounts of cold BSS. After the surgery, betamethasone, chloramphenicol, and diclofenac eye drops were used, and a lens dressing was applied. Patients were given acetaminophen codeine every 4 hours to reduce postoperative pain. Patients were examined on the first, third, and fifth days after surgery, and the dressing was removed once the epithelium was healed. Preservative-free artificial tears were started every 2 hours if needed after removing the dressing. Chloramphenicol eye drops were discontinued one week after surgery if the epithelial defect was completely healed. Betamethasone eye drops were switched to fluorometholone eye drops after the first postoperative week and eventually discontinued over a three-month period (every 6 hours in the first month, every 8 hours in the second month, and every 12 hours in the third month). We recorded patients' demographic data, examination information including uncorrected distance visual acuity (UDVA), corrected distance visual acuity (CDVA), haze, manifest and cycloplegic refraction, and central corneal thickness (CCT) preoperatively, at 3 months, and at 6 months postoperatively. We also recorded surgical information including ablation depth, ablation zone, and duration of mitomycin C usage.

Statistical Analysis

The data were described using mean, standard deviation, median, range, frequency, and percentage. T-test, Mann-Whitney test, and chi-square test or Fisher's exact test were used to compare the preoperative and postoperative results. Statistical analysis was performed using SPSS version 25 software (IBM, Armonk, NY, USA), and p-values less than 0.05 were considered statistically significant.

Results

Seventy-four eyes of 42 patients with a mean age of 34 ± 9 years (range 21 to 52 years) were included in the study. Among the patients, 54.8 % were female and 45.2 % were male (Table 1). The mean corrected distance visual acuity (CDVA) before surgery was 0.03 ± 0.06 LogMAR. The mean uncorrected distance visual acuity (UDVA) was 0.55 ± 0.25 LogMAR. The average preoperative corneal thickness was 548 ± 34 micrometers.

Table 1: Demographic findings of patients entering the study

Variable		Findings
Sex (Number, %)	Male	19 (45.2 %)
	Female	23 (54.8 %)
Age		34 ± 9
		32 (21,52)
CDVA (LogMAR)		0.03 ± 0.06
		0 (0,0.22)
UDVA (LogMAR)		0.55 ± 0.25
		0.52 (0.15,1)
Corrected hyperopia		2.76 ± 1.73
		2.5 (0.5,6)
Corrected astigmatism		-1.75 ± 1.58
		-1.75 (-5.75,0)
Axis		67.93 ± 75.03
		23.5 (0,180)
Modified spherical equivalent		1.88 ± 2.16
		2.25 (- 2.25,6)
Corneal Thickness		548 ± 34
		541 (475,640)

CDVA: Corrected Distance Visual Acuity
UDVA: Uncorrected Distance Visual Acuity

The predictive value for surgical outcomes at six months post-operation was 71.6 % within ± 0.5 diopter range, 89.2 % within ± 1 diopter range, and 97.3 % within ± 2 diopter range. Six months after the operation, 52.7 % of eyes achieved UCVA of 20/20, and 93.2 % achieved UCVA of 20/40 or better. None of the eyes experienced a loss of two or more lines of CDVA preoperatively, while 12 eyes (16.6 %) had a one-line CDVA loss. There was no statistically significant difference in CDVA before and after the operation, but the UDVA showed a significant improvement six months postoperatively ($P < 0.001$) (Table 2).

Discussion

Advancements in corneal surface ablation techniques such as LASIK and PRK, including the use of flying-spot instead of broad-beam devices, optical area enlargement, mitomycin C application, and wavefront-optimized software, have led to several improvements in surgical outcomes. These include reduced operation time, improved vision, diminished postoperative pain, decreased corneal opacity, and prevention of corneal flap complications [16]. In our study, the predictive value for surgical outcomes at six months post-operation was higher compared to previous studies using different excimer laser devices. The success rates have increased over time with the utilization of newer devices and methods. For instance, in 2004, O'Bart et al., [6] reported that 67 % of patients who underwent PRK for hyperopia using Apex plus excimer laser achieved a postoperative refractive error within ± 1 diopter range, with varying results based on the preoperative refractive error. Similarly, other studies also reported improvements in success rates over time [17-19]. It is worth noting that in our study, the Allegretto EX500 laser was used, which

Table 2: Visual acuity before and after PRK among hyperopic patients undergoing photorefractive keratectomy using allegretto EX500 excimer laser

Visual acuity	Time		P value *
	Pre operation	Post operation	
CDVA (LogMAR)	0.03 ± 0.06	0.03 ± 0.05	0.243
UDVA (LogMAR)	0.55 ± 0.25	0.11 ± 0.14	<0.001

CDVA: Corrected Distance Visual Acuity
UDVA: Uncorrected Distance Visual Acuity

has a high ablation speed of 500 Hz. The significant improvement in results compared to previous studies might be attributed to this high ablation speed. The Allegretto EX500 has a fast response to eye movements (approximately 0.2 seconds) using a 1000 Hz transducer. This rapid tracking speed is particularly advantageous for longer ablations required to correct hyperopia. It enhances the precision of tissue resection, minimizing the chances of irregularities and contributing to better visual outcomes [19].

Conclusion

Our study results show favorable surgical outcomes in terms of visual acuity after PRK using the Allegretto EX500 laser for treatment of hyperopia. The high predictive value and significant improvement in UDVA six months postoperatively indicate the effectiveness of this technique. Further studies with larger sample sizes and longer follow-up periods are warranted to validate these findings and explore potential factors influencing surgical outcomes.

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Footnotes and Financial Disclosures

Conflict of interest:

The authors declare no conflict of interest regarding the subject matter of the present study.