Post-laser *in-situ* keratomileuses effects on visual field in myopia and myopic astigmatism

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Background
The suction used during the laser insitu keratomileusis (LASIK) procedure necessary for cutting of the cornea by an oscillating blade induces an increase of intraocular pressure (IOP) to approximately 60 mm Hg or even more. This acute increase in IOP during LASIK may endanger the blood flow within the retinal vessels and induce visual field (VF) depression.

Purpose
To identify the effect of LASIK on the visual field parameters.

Settings
Prospective interventional case series study performed in ELNOOR ophthalmology center. From October 2015 to October 2016.

Methods
Prospective interventional case series study including patients with myopia and myopic astigmatism who were deemed candidates for LASIK correction. All recruited patients underwent visual field examination immediately before,1 week and 3 months post LASIK using Humphrey 750 Visual Field Analyzer (Zeiss Humphrey Systems, San Leandro, CA, USA), with a white-on-white Swedish Interactive Threshold (SITA). LASIK procedure was done using Allegretto device (wave light EX500, ALCON, Fort Worth, TX, USA) and Moria microkeratome (MM2).

Results
60 eyes of 30 patients were included in our study. Mean age was 28 + 5.6 years (range20-41), mean spherical equivalent (S.E) was -6.1 + 3.2 D (Range -1.4 to -15.1D), mean axial length was 23.5 + 1.5mm (Range 21-26.3mm). Humphrey global indexes included MD and PSD. The MD index estimates the uniform part of VF deviation, while the PSD index estimates the non-uniform part of VF deviation, reflecting the amount of localized depression of the VF. We found that (MD) shows slight decrease 1-week postoperative which is statistically significant, then improved 3 months postoperative with no statistical significant difference between preoperative and 3 months postoperative values. As regards PSD we found that there is no statistical difference between preoperative,1 week and 3 months postoperative.

Conclusion
The surgery of LASIK is safe and efficient, but surgeons should choose effective and safe suction mode, shorten the suction time and exclude potential retinopathy and preexisting glaucoma before surgery to improve the safety and efficacy. We found that LASIK procedure has no significant effect on visual field parameters, except for diffuse depression that occurs in the first week postoperative.

Keywords:
humphery visual field analyzer, laser *in situ* keratomileusis, myopia, suction

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Introduction

Laser in-situ keratomileuses (LASIK) can correct refractive errors surgically with a high degree of both safety and efficacy [1]. The wide range of correction, the accuracy of the results, and the speed of visual recovery after the surgery have made the procedure the most revolutionary breakthrough in ophthalmology since the 1990s and the most frequent refractive surgical procedure worldwide. The procedure consists of a microkeratome with a suction ring, which is followed by laser ablation of the cornea to reach the desired refractive effect [2,3].

Most of the reported LASIK complications are focused on the refractive outcome and anterior segment damage. Posterior segment complications are rarely reported after LASIK [4], because of most reports on the complications of LASIK are published by refractive surgeons. As vitreoretinal disorders are usually managed by retinal subspecialists, refractive surgeons may not be as aware of posterior segment complications and their outcome. This is because of that retinal specialists manage these drawbacks. So posterior segment examination before LASIK is mandatory [5].

Posterior segment complications are rarely described after LASIK such as posterior vitreous detachment, choroidal neovascular membrane, retinal detachment, macular hole, and optic nerve diseases. It is difficult to determine the incidence and risk factors of vitreoretinal complications because they occur occasionally [6].

Several studies have tried to explain the following three mechanisms for vitreoretinal alterations and optic nerve damage. The first mechanism is the excessive mechanical stress caused by application of the microkeratome to the globe. Moreover, the suction ring fixating the globe causes a change in the ocular contour. Additionally, the suction itself induces an increase of intraocular pressure (IOP) to ~60 mmHg or even more during the cutting of the cornea by an oscillating blade [5]. This acute increase in IOP during LASIK may endanger the blood flow within the retinal vessels and induce reversible visual field (VF) depression in normal and glaucomatous eyes [7].

Second, the time needed for creating the flap (cutting time depends on the type of microkeratome) and the surgeon's experience. The more the suction time, the higher incidence of vitreoretinal pathologies [5].

The final mechanism is the excimer laser shock waves generated within the globe which is responsible for stromal ablation. It was found that the excimer laser provokes a shock wave velocity of 3.3 km/s at 40 ns, and this leads to the development of pressure of up to 100 atm, which in turn causes mechanical stress to the eye [4].

In this study, we are trying to identify if LASIK is affecting the optic nerve through analyzing the VF parameters before and after LASIK procedure.

Patients and methods

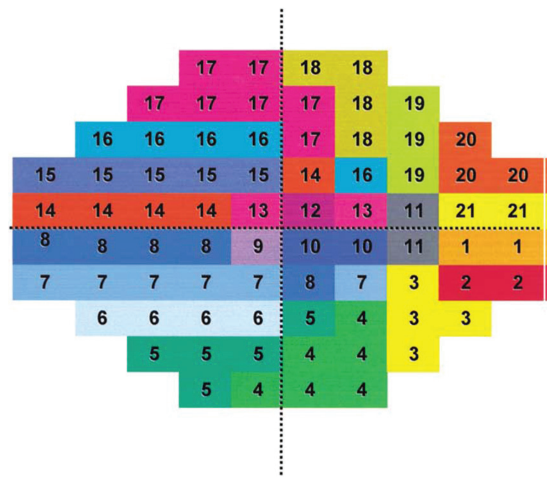
This was a prospective interventional case series study performed in El-Noor Ophthalmic Center from October 2015 to October 2016. All the procedures were conducted in accordance with the principles of the Helsinki Declaration. Informed consent was obtained from each patient approved by the Faculty of Medicine Research Ethics committee.

The inclusion criteria were an absence of ophthalmic disease other than myopia or myopic astigmatism, no family history of glaucoma or ocular hypertension, age greater than 18 years, and normal fundus examination. The exclusion criteria were patients with an organic pathology that could affect the regenerative process of the cornea (e.g. diabetes mellitus, diseases of the immune system, collagen-related disease) or with a self-reported history of cardiovascular disease or those with a previous ocular surgery. We also exclude those with a preoperative pachymetry of less than 450 μm, corneal topographic alterations, or lens opacities from this study. Furthermore, patients who experienced any complications during LASIK procedure and those with missed follow-up were excluded. Participants were excluded if the best spectacle corrected visual acuity in the eye to be tested was worse than 20/40, to ensure the correct fixation during perimetric examinations.

All patients underwent a complete medical and ocular history and preoperative examination including uncorrected visual acuity, best-corrected visual acuity, manifest and cycloplegic refraction (KR.7000-P; Topcon Corporation, Tokyo, Japan), slit-lamp examination (Haag-Streit, Switzerland, USA), applanation tonometry (Goldmann Applanation Tonometer, USA), fundus biomicroscopy, Scheimpflug imaging (oculus pentacam), indirect ophthalmoscopy, and VF testing through Humphrey static perimetry.

Overall, 60 eyes of 30 patients with myopia or myopic astigmatism were prepared for LASIK treatment. Four eyes were excluded from the study: one eye had an intraoperative flap complication (button hole flap) that prevented laser ablation, two eyes had interface infiltration, and one eye had flap striae. This causes decreased visual acuity on second day postoperatively.

Figure 1



Twenty-one clusters derived from 76 points of the Humphrey central 30-2 test. Each color indicates the same cluster area [17].

Two hours before the LASIK procedure, 1 week after LASIK, and 3 months after LASIK, conventional automated static perimetry was performed using a Humphrey 750 Visual Field Analyzer (Zeiss Humphrey Systems, San Leandro, California, USA), with a white-on-white Swedish interactive threshold.

The examiner explained the procedure to the patient. The standard program for glaucoma on the Humphrey is the 30-2. In the 30-2 program, the central 30° of the VF is tested (Fig. 1). The target is randomly presented to 76 points within the central 30° of VF with 6° of separation between locations, apart.

The Humphrey program 30-2 has been more extensively used, gives more information, and better age-specific comparison data. Tests were performed in all the examinations with the same machine. Participants were tested wearing their appropriate distance refraction correction and adequate near refraction placed in the lens holder throughout the examination, and because each additional corrective lens is a potential source of a ring scotoma, we used the spherical equivalent when the cylindrical correction was lower than 1.25 diopters.

Participants were required to be experienced in VF examination, having been tested at least twice previously using the Humphrey visual field analyzer to enhance the reliability of the assessment and to eliminate the learning effect on VF testing. Accordingly, the first baseline VF examination in all patients was discarded to rule out the learning effect that occurs with perimetry and to reduce the probability of finding imprecise data that may misleadingly indicate the presence of VF defects. We excluded any fixation losses and false-negative errors greater than 20% and false-positive errors less than 5%, and repeated it. Each patient's fixation and position were checked continuously by the perimetrist on the video eye monitor, with adjustments made as necessary. Each test was conducted by the same experienced technician.

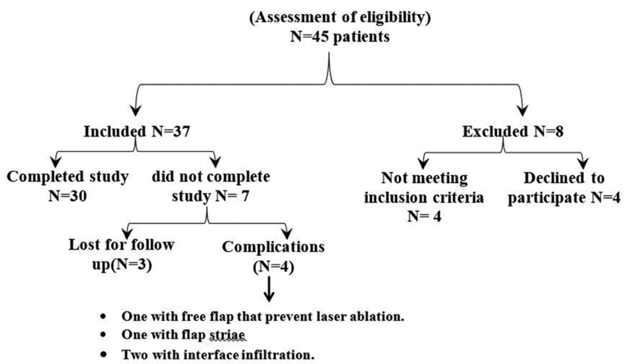
The analysis of the VF parameters was carried out and interpreted following the mathematical procedure described by Heijl *et al.* [8], both before LASIK and 1 week and 3 months after LASIK. Calculations of the total and pattern deviation plots and global indices were performed using StatPac (Sweden) for Swedish interactive threshold version A12.3. In this way, dependent variables of the VF global indices were evaluated: variations in mean deviation (MD) (a global index that reflects the overall depression in the VF), and pattern standard deviation (PSD) (a global index that reflects the amount of localized, rather than diffuse depression of the VF), the glaucoma hemifield test, and the number of depressed points deviating at *P* less than 5%, 2%, 1%, and 0.5% on the pattern deviation probability maps were determined and compared between baseline and subsequent VF tests.

Surgical technique

The Allegretto wave excimer laser device (Alcon Laboratories Inc., Fort Worth, Texas, USA) using standard ablation algorithms and the Moria Carriazo-Barraquer microkeratome with a turbine motor was used. We operated LASIK patients using topical anesthesia. The microkeratome Moria M2 110 μm head (Moria M2) was used to create an 8.5-mm diameter corneal flap with a superior hinge. It was used to attempt a flap thickness of 110 μm based on previous experience. The microkeratome advanced across the cornea and was stopped by an automatic stopper. It was removed from the suction ring, leaving the flap in place. Suction was stopped, and the ring removed.

After lifting the flap, ablations were performed using the Allegretto device (wave light EX500, ALCON, Fort Worth, TX, USA), with ablations being done using an aspheric multizone algorithm (optical zone size ranged from 6.0 to 6.5 mm), with a 6.0 and 0.5-mm transition zone. The corneal flap and stroma surface were irrigated with balanced normal saline

Figure 2



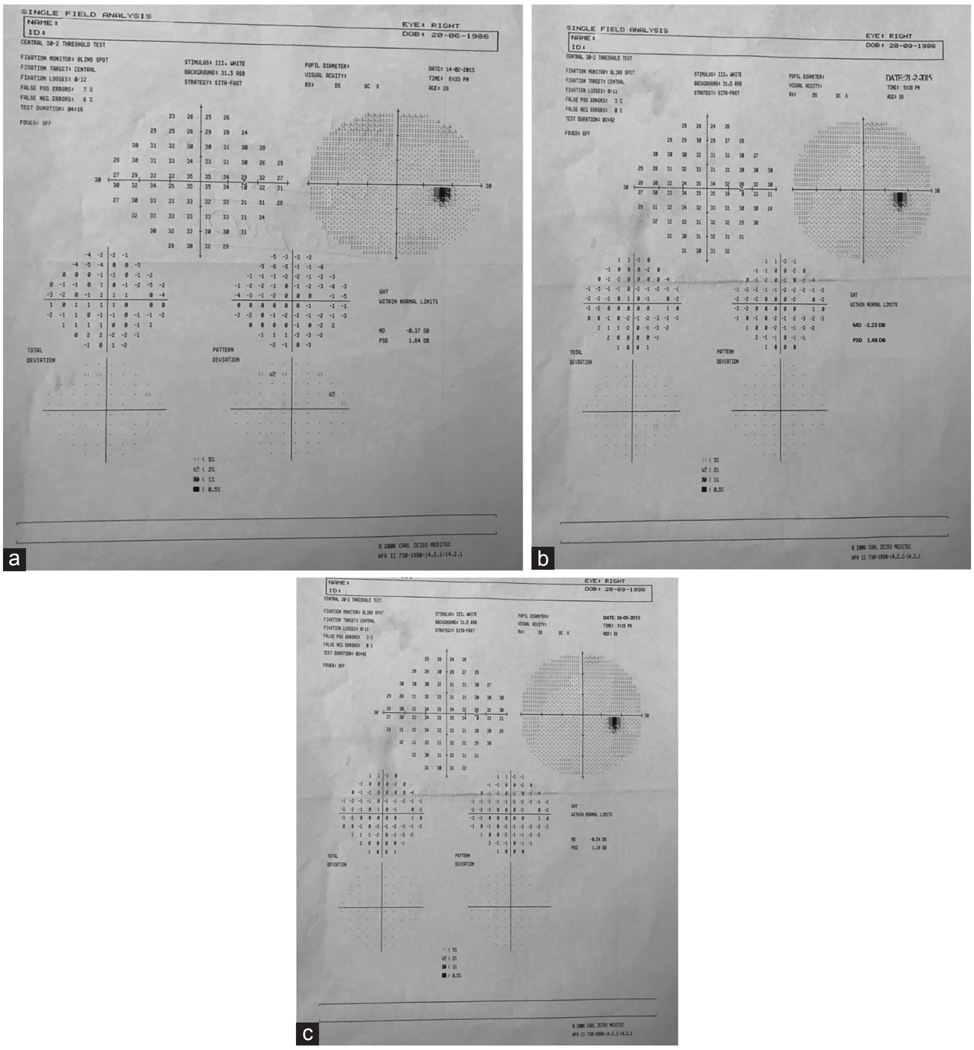
Flow chart of patients.

Table 1 The difference between visual field parameters preoperatively and 1 week postoperatively

	Preoperative		1 week		Mean difference	95% confidence interval of the difference		*P*
	Mean	SD	Mean	SD		Lower	Upper	
Mean deviation	−1.22	1.14	−1.74	1.22	−0.520	−0.0967	0.9433	0.0165*
PSD	2.21	1.14	2.48	1.11	0.114	−0.1334	0.6743	0.1876

PSD, pattern standard deviation. **P*<0.05, statistically significant difference.

Figure 3



(a) Swedish interactive threshold. Algorithm standard results obtained in a patient before laser in-situ keratomileusis (LASIK). (b) Swedish interactive threshold. Algorithm standard results obtained 1-week –after LASIK. (c) Swedish interactive threshold. Algorithm standard results obtained 3 months –after LASIK.

Table 2 The difference between visual field parameters preoperatively and 3 months postoperatively

	Preoperative		After 3 months		Mean difference	95% confidence interval of the difference		*P*
	Mean	SD	Mean	SD		Lower	Upper	
Mean deviation	−1.22	1.14	−1.43	1.12	−0.210	−0.6151	0.1951	0.3068
PSD	2.21	1.14	2.35	1.18	0.140	−0.2759	0.5559	0.5064

PSD, pattern standard deviation.

Table 3 Comparison of the test time, the reliability indexes, mean deviation, pattern standard deviation, and glaucoma hemifield test, between 1 week and 3 months postoperative

	1 week		After 3 months		Mean difference	95% confidence interval of the difference		*P*
	Mean	SD	Mean	SD		Lower	Upper	
Mean deviation	−1.74	1.22	−1.43	1.12	0.310	−0.1098	0.7298	0.1464
PSD	2.84	1.11	2.35	1.18	0.130	−0.5407	0.2807	0.5320

PSD, pattern standard deviation.

solution, and the flap was repositioned, and the flap edge was dried with a micro sponge. Postoperatively the patients were instructed to instill dexamethasone 0.1% five times per day for 1 week, gatifloxacin five times daily for 2 weeks, and artificial tears 5 times per day for 3 months.

Statistical analysis

Test for normal distribution was performed using Shapiro–Wilk test. Our data were normally distributed, and we performed the statistical analysis by using paired *t*-tests and SPSS analysis (SPSS Inc., Chicago, Illinois, USA). P value less than 0.05 was considered statistically significant. The results of our study are presented as mean and SD values where applicable, and measured ranges indicate minimums and maximum.

Results

The study included 60 eyes of 30 patients (Fig. 2), with 10 (32.3%) males. The age of the patients ranged from 20 to 41 years, with mean of 28.1 ± 5.6 years. The manifest spherical equivalent refraction ranged from −1.4 to −15.1 diopters, with mean of −6.1 ± 3.2. The mean suction time was 26 ± 2.19 s, whereas the mean IOP was 14.10 ± 1.69 mmHg. The axial length ranges from 21 to 26.3 mm, with mean of 23.5 ± 1.5.

Our results for preoperative and postoperative automated perimetry show a transitory decrease in some VF indexes 1 week and 3 months after the LASIK procedure (Fig. 3). We found that MD shows slight decrease 1 week postoperatively, which is statistically significant (Table 1), and then improved 3 months postoperative, with no statistical significant difference between preoperative and 3 months postoperative values (Tables 2 and 3).

Regarding PSD, we found that there is no statistical difference between preoperative and 1 week and 3 months postoperative values (Tables 1–3).

Discussion

LASIK has become the most popular refractive procedure for treatment of ametropia. During this procedure, IOP increase to higher than 65 mm hg to create a precise lamellar corneal flap [9].

This is highly attributed to central retinal arterial hemodynamics which may diminish perfusion of the retina and optic nerve head [10].

In our study, we included 61 eyes of 31 patients with low, moderate, and high myopia who underwent LASIK surgery. These patients had no family history of glaucoma or any evidence of increased cup-disc ratio or did not have any systemic abnormalities such as diabetes, hypertension, or hyperlipidemia.

Perimetry was performed before and 1 week and 3 months after LASIK. MD and PSD were recorded.

We found that MD decreased 1 week postoperatively, but with a statistical significant difference, and also there is no statistical difference between preoperative and 3-month postoperative values.

Regarding PSD, we found that there is no statistical difference between preoperative and 1-week and 3-month postoperative values.

We noticed that VF modifications in our study were diffuse defects rather than localized.

This may be attributed to decreased contrast sensitivity in the midperipheral VF owing to optical factors related to corneal aberration rather than optic nerve or retinal nerve fiber layer damage.

We exclude the possibility of optic nerve and macular lesion by fundus examination and exclude the possibility of defocus error as it was measured and corrected during VF examination.

We also exclude an important issue that may cause the decreased VF sensitivity after LASIK, which is flap edema in the early postoperative period.

Cardona Ausina *et al*. found that the recovery took at least 3 months after LASIK, with an improvement at 6 months for spatial frequencies of three and six cycles per degree and at 12 months an improvement for 3, 6, and 18 cycles per degree [11].

In agreement with our study, Yuan *et al*. studied 92 eyes of 46 patients with mild, moderate, and high degrees of myopia who underwent LASIK. Perimetry was performed before and 1 day, 1 month, 3 months, and 6 months after LASIK surgery. MD and PSD were recorded. No complications were found in the participants. IOP was normal at all preoperative and postoperative examinations. MD showed significant differences among preoperative and postoperative values and was correlated with visual acuity post-LASIK significantly. However, PSD did not show significant differences before and after LASIK and was not correlated with visual acuity post-LASIK. The authors concluded that no significant VF change was demonstrated before LASIK and after LASIK after 6 months of follow-up. The study suggests that LASIK does not affect the retinal physiological functions [12].

Moreover, in 2007, a prospective study involved 94 eyes that underwent a conventional LASIK procedure. A complete eye examination was carried out in which the IOP measurement and VF were tested before LASIK and 6 and 12 months after LASIK. Patients were divided into two subgroups according to their refractive error (low and high myopia group). The VF modifications in this study were diffuse defects, rather than localized. In the low myopia group, there were no significant differences in the analyzed variables, except a slight decrease in MD when comparing results before and 6 months following LASIK that returned to baseline values at 12 months after surgery [13].

On the contrary, Bushley *et al*. reported a 28-year-old woman who developed a VF defect in one of her eyes after bilateral LASIK that persisted 1 year after the procedure. Preoperatively, the patient was highly myopic (−10 D) with a family history of normal tension glaucoma, and both eyes had normal IOP and VF.

At the first postoperative visit (day 1), the patient reported a scotoma in the right eye. At 3-month follow-up, VFs revealed the patient had developed a near-superior altitudinal VF defect in the right eye. The defect did not progress over 1 year of follow-up examinations. Because of temporal relationship between the two events, the authors hypothesize that the visual field defect was caused by an ischemic event at the optic nerve head during the procedure [14]. In our study, there is no family history of glaucoma, so we suggest that the optic nerve will not experience LASIK-induced barotrauma and ischemia in the absence of the risk factors that may render the optic nerve susceptible to damage. Patients who have risk factors for ischemic optic neuropathy like those with hypertension, diabetes, or hyperlipidemia. Weiss and colleagues recommend other refractive procedures such as photorefractive keratectomy without inherent increase of IOP for patients who have high-risk factors for ischemic optic disc head damage (age over 45–50 years, or with hypertension, diabetes or hyperlipidemia) and patients with family history of glaucoma or glaucomatous optic nerve damage (increased vertical cup-disc diameter ratio) [15,16].

Trible and Anderson stated that acute increase in IOP during LASIK is certainly sufficient to reduce or stop blood flow within the retinal vessels and could induce reversible VF depression in normal and glaucomatous eyes [7].

Ozdamar *et al*. found a slight decrease in threshold sensitivity in the central area at day 1 of VF examination, and they explained that it was because of flap edema in the early postoperative period. We did not find postoperative flap edema at 1 week after LASIK, and we do not believe this could explain our results [17].

The limitations to our study is that a controlled prospective study is needed to further address questions regarding the relationship between VF changes and contrast sensitivity evolution (possibly combined with a glare test), alterations to the peripheral retinal image quality, and LASIK procedures, especially as related to microkeratome application time.

Moreover, we did not divide the VF outcomes into central (0–15) and midperipheral (15–30), so we cannot confirm that the decreased sensitivity in the midperipheral VF seen after LASIK is owing to optical factors related to the corneal aberration rather than optic nerve or retinal nerve fiber layer damage from the microkeratome suction.

Conclusion

LASIK is safe and efficient, but surgeons should choose effective and safe suction mode, shorten the suction time, and exclude potential retinopathy and preexisting glaucoma before surgery to improve the safety and efficacy of LASIK. Despite the large number of surgeries performed worldwide, serious complications after LASIK are still infrequent, and no direct causal relationship has been established. It is very important to inform patients that LASIK only corrects the refractive aspect of myopia. The risk of vitreoretinal complications in these eyes is still present.

Thus, a detailed fundus examination is very important before LASIK and in every patient whose visual acuity after LASIK is not as good as expected to avoid delayed referral to a vireoretinal specialist if necessary.

LASIK procedure has no significant effect on VF parameters, except for diffuse depression that occurs in the first week postoperatively.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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