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New Scheimpflug camera device in measuring corneal power changes after myopic laser refractive surgery

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ABSTRACT

Purpose: To assess the accuracy of a combined Scheimpflug camera–Placido disk device (Sirius, CSO, Italy) in evaluating corneal power changes after myopic photorefractive keratectomy (PRK).
Methods: Two hundred and thirty-seven eyes of 237 patients that underwent myopic PRK with a refractive error, measured as spherical equivalent, ranging from −10.75 D to −0.5 D (mean −4.63 ± 2.21 D), were enrolled in this study. Corneal power evaluation using Sirius were performed before, 1, 3 and 6 months after myopic PRK. Mean simulated keratometry (SimK) and mean pupil power (MPP) were measured.

Correlations between changes in corneal power, measured with SimK and MPP, and variations in subjective refraction, calculated at corneal plane, were evaluated using Pearson test at every follow up; differences between preoperative and postoperative data were evaluated with the Student paired *t*-test.
Results: A good correlation has been detected between the variations in subjective refraction measured at corneal plane 1, 3 and 6 months after myopic PRK and both SimK ($R^2 = 0.8463$; $R^2 = 0.8643$; $R^2 = 0.7102$, respectively) and MPP ($R^2 = 0.6622$; $R^2 = 0.5561$; $R^2 = 0.5522$, respectively) but corneal power changes are statistically undervalued for both parameters ($p < 0.001$).
Conclusions: Even if our data should be confirmed in further studies, SimK and MPP provided by this new device do not seem to accurately reflect the changes in corneal power after myopic PRK.

1. Introduction

An accurate estimation of corneal power in patients that previously underwent refractive surgery can help us to understand whether an under-correction or overcorrection is due to an error in the excimer laser calibration, in the measurement of refraction before surgery and to design better ablation profiles for excimer laser refractive surgery. It is well accepted that the methods currently used to evaluate corneal power after radial keratotomy (RK), photorefractive keratectomy (PRK) or LASIK are unreliable [1–6]; moreover, a precise corneal power evaluation could allow a better intraocular lens (IOL) power calculation in these patients if they have to undergo cataract surgery, avoiding surprising results [7,8]. The introduction of instruments based on the use of a rotating Scheimpflug camera has proved to be very helpful in clinical practice to perform the evaluation of the anterior segment, as long as it provides information from the anterior corneal surface to the posterior lens surface [9]. Sirius (CSO, Firenze, Italy) is a new device combining a Placido-disk topographer and a rotating Scheimpflug camera, it is able to provide a complete and precise corneal scan in naïve eyes [10]. Accuracy in the evaluation of corneal power, central corneal thickness, anterior chamber depth, corneal asphericity, provided by Sirius and other Scheimpflug based devices, have been tested in small groups of keratoconus (KC) eyes and in eyes that underwent refractive surgery [10–14]. Sirius tomography system has provided highly repeatable measurements of anterior segment parameters in healthy eyes as well as KC ones and after myopic excimer laser surgery, but no comparison between before and after refractive surgery has been reported [10].

Since there are no evidences in current international literature about the reliability of this device in measuring corneal power after

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refractive surgery, the purpose of this study is to verify the accuracy of Sirius in corneal power evaluation after myopic PRK.

2. Methods

This retrospective study included 237 eyes of 237 patients (129 women and 108 men) that underwent myopic PRK with a mean age of 30.7 ± 7.92 years (range from 18 to 57 years).

Attempted spherical equivalent correction ranged from −10.75 D to −0.5 D (mean −4.63 ± 2.21 D); patients with systemic and ocular diseases that could interfere with the corneal healing process or with the refractive outcome, such as diabetes, connective tissue disorders, dry eye, uveitis, corneal and lens opacities and glaucoma, were excluded from the treatment. All surgical treatments were performed under topical anesthesia using oxybuprocaine eye drops (Novesina® Novartis Farma, Italy). The lids were opened with a speculum, the epithelium was debrided with a mechanical brush, all treatments were performed with an Allegretto Wave excimer laser system (WaveLight Laser Technologies AG, Erlangen, Germany). A bandage contact lens was applied under sterile conditions on the treated eye immediately following surgery and was left until complete re-epithelialization. During this period, the operated eye received the following medications: diclofenac sodium 0.1% eye drops twice a day for the first 2 days, nethylmicin preservative-free eye drops until re-epithelialization and preservative-free artificial tears for 1 month; after re-epithelialization, clobetasone eye drops were prescribed to all patients for 1 month four times a day. Preoperative and follow up examinations at 1, 3 and 6 months after PRK, included a comprehensive ophthalmologic examination and corneal power evaluation using Sirius tomography (software version 2.5) which, in addition to the Scheimpflug camera, uses a small-angle Placido-disk topographer with 22 rings. Profiles of anterior cornea, posterior cornea, anterior lens and iris derive from the Scheimpflug images, while data relating to the anterior surface are provided by the combination with the Placido images [9,10]. This system allows a fast and complete analysis of both cornea and anterior segment in one step. Three repeated consecutive, good quality, measurements were taken by the same experienced examiner and the average of the values detected has been utilized in the study.

The corneal parameters evaluated in this study have been mean simulated keratometry (SimK) and mean pupil power (MPP) because they are automatically provided by the instruments, so there are no bias related to physicians interpretation, moreover they have been proved to be reliable in naïve and keratoconus eyes [10,13].

Also if Sirius is able to evaluate posterior corneal curvature too, in this study it has been considered only anterior corneal evaluation because reliability of posterior corneal power measurements has not been proven. Moreover, even if Sirius is a device able to provide more other maps to evaluate anterior and posterior corneal surface, purpose of this study is to perform a comparison with some of the parameters physician are more familiar with.

Refraction and topographic analysis were performed by two independent observers.

Although most of the patients underwent surgery in both eyes, only right ones have been included in the study to avoid the introduction of bias depending on the strong relation that is usually possible to observe between the right and left eye of the same patient.

The normality of the distribution was tested with Kolmogorov–Smirnov test, the correlations between changes in corneal power, measured with SimK and MPP, and variations in subjective refraction, calculated at corneal plane, were statistically evaluated using the Pearson test and the differences between preoperative and post operative data were evaluated with the Student paired *t*-test using SPSS 18.0 (IBM Corp. Armonk, New York).

The corneal plane refraction has been calculated and used in comparison with Sirius parameters in order to reduce the possible bias in the comparison of differences with corneal power variations. Bland–Altman plots were used to identify any potential dependency between differences and means of the two measurements.[15,16] The study was performed in accordance with the ethical standards stated in the 1964 Declaration of Helsinki and approved by the local clinical research ethics committee; informed consent was obtained from all patients for both the surgery and the study.

3. Results

The effective treatment, calculated at corneal plane, 1 month after surgery was between −11.99 D and −0.99 D (mean −5.18 ± 2.41 D); 3 months after surgery, was between −11.8 D and −0.37 D (mean −5.05 ± 2.29 D), and 6 months after surgery was between −11.25 D and −0.37 D (mean: −4.9 ± 2.17 D); corneal power measured with both parameters at every follow up are summarized in Table 1. Differences in corneal power calculated with SimK and MPP at 1, 3, and 6 months follow-up are shown in Table 2. SimK changes showed a very good correlation with the variations in subjective refraction measured at corneal plane at 1, 3 and 6 months follow-up (R^2 = 0.8463; R^2 = 0.8643; R^2 = 0.7102, respectively) but effective treatment is undervalued, mainly for the higher ones. MPP changes showed a good positive correlation with the variations in

Table 1
Range, mean and standard deviation (SD) of Simulated keratometry (Sim'K) and mean pupil power (MPP) at 1, 3 and 6 months follow up (FU).

	SIMK		MPP	
	Range	Mean ± SD	Range	Mean ± SD
1 Month FU (D)	31.9; 43.9	39.2 ± 2.47	34.5; 44.2	40.6 ± 1.74
3 Month FU (D)	29.8; 44.2	39.3 ± 2.35	35.3; 44.2	40.7 ± 1.67
6 Month FU (D)	33.4; 44	39.5 ± 2.13	35.6; 44.3	40.8 ± 1.61

Table 2
Statistical comparison (*p*-value) between effective treatment measured at corneal plane and both simulated keratometry (SIMK) and both mean pupil power (MPP) changes, measured with Sirius, 1, 3 and 6 months after myopic PRK.

	Effective treatment		SIMK variation			MPP variation		
	Range	Mean ± SD	Range	Mean ± SD	*p*	Range	Mean ± SD	*p*
1 Month FU (D)	−11.99; −0.99	−5.18 ± 2.4	−11; −0.7	−4.61 ± 2.15	<0.01	−7.1; −0.8	−2.65 ± 1.26	<0.01
3 Month FU (D)	−11.8; −0.37	−4.99 ± 2.25	−11; −0.75	−4.44 ± 1.98	<0.01	−5.8; −0.4	−2.54 ± 1.13	<0.01
6 Month FU (D)	−11.25; −0.37	−4.9 ± 2.17	−11.3; 1.55	−4.28 ± 1.93	<0.01	−6.1; −0.3	−2.49 ± 1.12	<0.01