

Research Article

Change in Corneal Epithelial Thickness After Photo Refractive Keratectomy (PRK)

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Abstract

Purpose: The study of change of the epithelium of the cornea in two points after Photo Refractive Keratectomy (PRK): at the peak of the cornea (ETpeak) and in the middle of the cornea (ETcenter). The study of the change of Lower Order Aberrations (LOAs) and Higher Order Aberrations (HOAs), Contrast Sensitivity (CS) and Corrected Distance Visual Acuity (CDVA) and the relationship of these parameters with the change of ETpeak and ETcenter after PRK.

Materials and Methods: Twenty-seven patients (5 women and 22 men) with an average age of 27 years (age range 23-36) underwent PRK. For two years all 27 patients had stable refraction. The refractive objective was emmetropia.

Results: After PRK, a statistically significant difference was found between pre-surgery and post-surgery measurements of ETpeak and ETcenter with in relation to LOAs, HOAs, CS and CDVA. As well as between CS and HOA (Z33).

Conclusion: In conclusion, after PRK, the change in ETcenter and ETpeak is associated with the change in CDVA and the changes in LOAs and HOAs. Also, the change in CDVA is related to SC, LOAs and HOAS. Finally, the change in the ETcenter appears to be related to the change in the CS.

Keywords: PRK; Corneal Aberrations; ETcenter; ETpeak; CDVA; Contrast Sensitivity

Introduction

Photorefractive keratectomy appeared in the early 1980s and has since been one of the main refractive surgery techniques, especially for low myopia. It is very effective in correcting small degrees of myopia, with or without astigmatism. For the PRK method, a laser system (Excimer Laser) is used that is controlled by a computer and reshapes the surface of the cornea so that

objects are now focused on the retina, improving the clarity of vision. During this short procedure, which is painless and is performed using local anesthetic eye drops, the patient is lying down and his eyelids remain open with the help of an eyelid dilator. The degree of refractive error (e.g., myopia, hyperopia) is entered into the computer and using a special program, the degree of correction is calculated [1].

In this method, scraping mechanically removes the epithelium. Then the Bowman's layer and the other layer are subjected to the effect of laser radiation in order to achieve the appropriate change in curvature. A therapeutic contact lens is then placed on the cornea until the epithelium heals, which takes three to five days [1]. Post-operative pain and a slow recovery of vision are its main disadvantages. The main complication of the PRK technique is post-operative corneal haze. Corneal opacity is a result of the normal wound healing process. It appears 4-6 weeks postoperatively and then gradually subsides over the next 3-6 months (occasionally 1-2 years) [1,2]. The modified keratocytes transform into myofibroblasts that produce collagen, creating scar tissue. Post-PRK opacification becomes apparent due to light scattering by scar tissue and appears to be more severe as the depth of

resection increases [3]. Epithelial change and its effect on the results of corneal refractive surgery has been investigated [4]. An increase in corneal thickness after PRK has been shown in previous studies to occur immediately after the procedures and is detected at postoperative visits, which may be related to the possible regression of the refractive action that occurs mainly after PRK [4,5].

Materials and Methods

Twenty-seven patients (5 women and 22 men) with a mean age of 27 years (range 23-36) underwent PRK. For at least two years the patients had stable refraction. The refractive objective was emmetropia. Preoperative and postoperative examinations were performed on all patients. None of the patients included in the study presented complications during or after surgery. All patients underwent in a series of eye exams: uncorrected visual acuity measurement, Corrected Distance Visual Acuity (CDVA), cycloplegic refraction, non-contact intraocular pressure measurement and slit-lamp biomicroscopy. Changes in ETpeak and ET center were measured via the epithelial map of optical coherence tomography (Avanti XR OCT, Optovue). Three measurements were taken for each patient and their average value was used. Pentacam HR (Oculus GmbH, Wetzlar, Oculus, Germany) was used to measure corneal Zernike. CS as a mean of luminance gain between a small object and its background divided by the mean background luminance (SC Weber) and its logarithm (SC Logs), preoperatively and postoperatively, were obtained with the Freiburg Vision Test ('FrACT' vs. 3.9.3 · 2015-06-01 · F16.0) [4,5]. "FrACT" is a widely used visual test battery in the form of a free computer program with respect to objectivity and reliability, contrast sensitivity and Vernier acuity [4,5]. Only measurements where the test quality parameters appeared OK were selected. The same technician performed each examination in total darkness. Tests were performed before surgery and after surgery. The mean follow-up time was 12.18 +/- 1.48 (minimum 11 maximum 14) months. The local ethics committee approved of the study protocol. Written informed consent was obtained from all patients. Only one eye from each patient, specifically the right eye, was included in the study. Patients who had systemic diseases as well as pregnant patients were excluded from the study. This article is part of a larger investigation that studied corneal epithelial change after LASIK refractive surgery and after PRK refractive surgery. The results of the change of the corneal epithelium after refractive surgery in relation to the parameters CDVA, CS, HOAs and LOAs after LASIK refractive surgery have already been published. As has also been published the comparison between two techniques. This article exclusively studies the change of the corneal epithelium in relation to the parameters CDVA, CS, HOAs and LOAs after PRK.

Statistical Method

The Shapiro-Wilk test was used to assess the normal distribution of the parameters. All continuous variables had non-normal distribution and are expressed as median (range). Categorical variables are presented as frequencies or percentages. The Spearman correlation coefficient was used to evaluate associations between continuous variables. A p-value <0.05 (two-tailed) was considered to indicate a statistically significant difference. Statistical analysis was conducted using IBM SPSS-Statistics version 29.0 (IBM Corp).

Results

Twenty-seven patients (5 females and 22 males) with a median age of 27 years (range 23-36) underwent PRK. The characteristics of the study population are displayed in the Table 1.

Variable	Median	Minimum	Maximum
Age (years)	27	23	36
ODCDVA (logMar) preop	-0.160	-0.160	0.070
ODCDVA (logMar) 12 months	-0.130	-0.160	0.290
ODSC (weber) preop	0.000	-1.780	2.110
ODSC (weber) 12 months	0.380	0.220	2.360
ODCS (logcs) preop	2.290	1.630	7.770
ODCS (logcs) 12 months	2.330	1.630	2.650
ODETcenter (µm) preop	54	46	68
ODETcenter (µm) 12 months	53	47	68
ODETpeak (µm) preop	54	45	68

ODETpeak (μm) 12 months	54	48	68
ODz00 preop	134.93	111.216	161.105
ODz00 12 months	133.06	111.216	161.105
ODz11 preop	1.528	0.494	5.893
ODz11 12 months	1.368	0.214	5.893
ODz02 preop	79.037	66.655	95.948
ODz02 12 months	78.951	66.655	95.948
ODz22 preop	1.013	0.378	2.440
ODz22 12 months	0.821	0.222	1.684
ODz31 preop	0.319	0.054	0.823
ODz31 12 months	0.333	0.081	0.823
ODz33 preop	0.193	0.039	1.285
ODz33 12 months	0.215	0.067	1.285
ODz40 preop	1.743	0.847	2.757
ODz40 12 months	1.487	0.847	2.757
ODz42 preop	0.117	0.019	3.510
ODz42 12 months	0.159	0.021	0.302
ODz44 preop	0.100	0.029	0.437
ODz44 12 months	0.108	0.021	0.437
Gender	N	%	
Females	5	18.5	
Males	22	81.5	
*OD: right eye; CDVA: Corrected Distance Vision Acuity; SC: Sensitivity Contrast; CS: Contrast Sensitivity; logcs: log of CS; ET peak: Epithelial thickness changes at the corneal apex; ET center: Epithelial Thickness changes at the center of the cornea; preop: preoperative			

Table 1: Characteristics of the study population.

The median values of variance of different variables (value at 12 months-value at the preoperative period) are displayed in Table 2.

Variable	Median	Minimum	Maximum
ODCDVAD (log Mar)	0.000	-0.230	0.450
ODSCD (weber)	0.550	0.220	2.360
ODCSD (logcs)	0.000	-6.000	0.890
ODETcenterD (μm)	0.000	-18.00	18.00
ODETpeakD (μm)	0.000	-18.00	17.00
ODz00D	-0.090	-40.49	29.97
ODz11D	-0.160	-24.84	17.29
ODz22D	-0.224	-1.490	1.270
ODz31D	0.039	-0.510	0.510
ODz33D	-0.010	-1.160	1.050
ODz40D	-0.297	-1.610	1.670
ODz42D	0.025	-0.140	0.280
ODz44D	-0.014	-0.360	0.350
*OD: right eye; CDVA: Corrected Distance Vision Acuity; SC: Sensitivity Contrast; CS: Contrast Sensitivity; logcs: log of CS; ET peak: Epithelial Thickness changes at the corneal apex; ET center: Epithelial Thickness changes at the center of the cornea			

Table 2: Median values of the variance of different variables (value at 12months-value at the preoperative period).

Regarding the OD, there was a statistically significant positive correlation between the median value of CDVAD (logMar) and the median value of z00D (Spearman's rho:0.647, p=0.001), between the median value of CDVAD (logMar) and the median value of z02D (Spearman's rho:0.626, p=0.001), between the median value of SCD (weber) and the median value of CSD (logcs) (Spearman's rho:0.410, p= 0.034), between the median value of SCD (weber) and the median value of ETcenterD (μm) (Spearman's rho: 0.488, p=0.010), between the median value of ETcenterD (μm) and the median value of ETpeakD (μm) (Spearman's rho: 0.885, p=0.001), between the median value of ETcenterD (μm) and the median value of z31D (Spearman's rho: 0.402, p=0.038), between the median value of ETcenterD (μm) and the median value of z40D (Spearman's rho: 0.612, p=0.001), between the median value of ETcenterD (μm) and the median value of z42D (Spearman's rho: 0.454, p=0.017), between the median value of ETpeakD (μm) and the median value of z11D (Spearman's rho: 0.405, p=0.036), between the median value of ETpeakD (μm) and the median value of z31D (Spearman's rho: 0.501, p=0.008), between the median value of ETpeakD (μm) and the median value of z40D (Spearman's rho: 0.652, p=0.001), between the median value of ETpeakD (μm) and the median value of z42D (Spearman's rho: 0.417, p=0.030), between the median value of z00D and the median value of z02D (Spearman's rho: 0.982, p=0.001), between the median value of z00D and the median value of z22D (Spearman's rho: 0.435, p=0.023), between the median value of z11D and the median value z31D (Spearman's rho: 0.659, p=0.001), between the median value of z11D and the median value of z40D (Spearman's rho: 0.721, p=0.001), between the median value of z02D and the median value of z22D (Spearman's rho: 0.413, p=0.032), between the median value of z22D and the median value of z44D (Spearman's rho: 0.455, p=0.017) and between the median value of z31D and the median value of z40D (Spearman's rho: 0.387, p=0.046).

We also observed a statistically significant negative correlation between the median value of CDVAD (logMar) and the median value of SCD (weber) (Spearman's rho:-0.407, p=0.035), between the median value of CDVAD (logMar) and the median value of ETpeakD (μm) (Spearman's rho:-0.419, p=0.030), between the median value of CDVAD (logMar) and the median value of ETcenterD (μm) (Spearman's rho:-0.404, p=0.037), between the median value of CDVAD (logMar) and the median of z40D (Spearman's rho:-0.645, p=0.001), between the median value of CSD (logcs) and the median value of z33D (Spearman's rho: -0.516, p=0.006), between the median value of ETcenterD (μm) and the median value of z00D (Spearman's rho: -0.512, p=0.006), between the median value of ETcenterD (μm) and the median value of z02D (Spearman's rho: -0.479, p=0.011), between the median value of ETpeakD (μm) and the median value of z00D (Spearman's rho: -0.562, p=0.002), between the median value of ETpeakD (μm) and the median value of z02D (Spearman's rho:-0.521, p=0.005), between the median value of z00D and the median value of z40D (Spearman's rho: -0.565, p=0.002) and between the median value of z02D and the median value z40D (Spearman's rho: -0.527, p=0.005 (Table 3).

Variable		ODCDV A (logMar	ODSC D (weber)	ODCS D (logcs)	ODETcenterD (μm)	ODETpeakD (μm)	ODz00D	ODz11D	ODz02D	ODz22D	ODz31D	ODz33D	ODz40D	ODz42D	ODz44 D
ODCDVAD (logMar)	Spearman's rho	1.000	-0.407	-0.354	-0.404	-0.419	0.647	-0.317	0.626	0.262	-0.096	0.012	-0.645	-0.278	0.362
	p	.	0.035	0.070	0.037	0.030	0.001	0.107	0.001	0.187	0.634	0.953	0.001	0.161	0.063
ODSCD (weber)	Spearman's rho	-0.407	1.000	0.410	0.488	0.354	-0.252	0.009	-0.221	-0.210	0.191	-0.274	0.295	0.298	-0.316
	p	0.035	.	0.034	0.010	0.070	0.205	0.966	0.267	0.294	0.340	0.167	0.135	0.131	0.109
ODCSD (logcs)	Spearman's rho	-0.354	0.410	1.000	0.325	0.323	-0.185	0.013	-0.144	-0.346	0.031	-0.516	0.247	-0.050	-0.329
	p	0.070	0.034	.	0.098	0.101	0.355	0.951	0.472	0.077	0.877	0.006	0.214	0.805	0.094
ODETcenterD (μm)	Spearman's rho	-0.404	0.488	0.325	1.000	0.885	-0.512	0.319	-0.479	-0.336	0.402	-0.048	0.612	0.454	-0.214
	p	0.037	0.010	0.098	.	0.001	0.006	0.105	0.011	0.086	0.038	0.814	0.001	0.017	0.284
ODETpeakD (μm)	Spearman's rho	-0.419	0.354	0.323	0.885	1.000	-0.562	0.405	-0.521	-0.326	0.501	-0.155	0.652	0.417	-0.323
	p	0.030	0.070	0.101	0.001	.	0.002	0.036	0.005	0.097	0.008	0.441	0.001	0.030	0.101
ODz00D	Spearman's rho	0.647	-0.252	-0.185	-0.512	-0.562	1.000	-0.337	0.982	0.435	-0.241	0.103	-0.565	-0.281	0.225
	p	0.001	0.205	0.355	0.006	0.002	.	0.086	0.001	0.023	0.226	0.609	0.002	0.156	0.259
ODz11D	Spearman's rho	-0.317	0.009	0.013	0.319	0.405	-0.337	1.000	-0.314	0.081	0.659	0.256	0.721	0.359	0.256
	p	0.107	0.966	0.951	0.105	0.036	0.086	.	0.111	0.689	0.001	0.197	0.001	0.066	0.198

ODz02D	Spearman's rho	0.626	-0.221	-0.144	-0.479	-0.521	0.982	-0.314	1.000	0.413	-0.228	0.050	-0.527	-0.250	0.248
	p	0.001	0.267	0.472	0.011	0.005	0.001	0.111	.	0.032	0.252	0.804	0.005	0.208	0.211
ODz22D	Spearman's rho	0.262	-0.210	-0.346	-0.336	-0.326	0.435	0.081	0.413	1.000	0.144	0.263	-0.208	-0.107	0.455
	p	0.187	0.294	0.077	0.086	0.097	0.023	0.689	0.032	.	0.473	0.185	0.299	0.597	0.017
ODz31D	Spearman's rho	-0.096	0.191	0.031	0.402	0.501	-0.241	0.659	-0.228	0.144	1.000	0.021	0.328	0.387	-0.029
	p	0.634	0.340	0.877	0.038	0.008	0.226	0.001	0.252	0.473	.	0.916	0.095	0.046	0.887
ODz33D	Spearman's rho	0.012	-0.274	-0.516	-0.048	-0.155	0.103	0.256	0.050	0.263	-0.021	1.000	0.243	-0.088	0.325
	p	0.953	0.167	0.006	0.814	0.441	0.609	0.197	0.804	0.185	0.916	.	0.222	0.664	0.098
ODz40D	Spearman's rho	-0.645	0.295	0.247	0.612	0.652	-0.565	0.721	-0.527	0.208	0.328	0.243	1.000	0.369	0.023
	p	0.001	0.135	0.214	0.001	0.001	0.002	0.001	0.005	0.299	0.095	0.222	.	0.058	0.909
ODz42D	Spearman's rho	-0.278	0.298	-0.050	0.454	0.417	-0.281	0.359	-0.250	-0.107	0.387	-0.088	0.369	1.000	0.042
	p	0.161	0.131	0.805	0.017	0.030	0.156	0.066	0.208	0.597	0.046	0.664	0.058	.	0.837
ODz44D	Spearman's rho	0.362	-0.316	-0.329	-0.214	-0.323	0.225	0.256	0.248	0.455	-0.029	0.325	0.023	0.042	1.000
	p	0.063	0.109	0.094	0.284	0.101	0.259	0.198	0.211	0.017	0.887	0.098	0.909	0.837	.

*OD: right eye; CDVA: Corrected Distance Vision Acuity; SC: Sensitivity Contrast; CS: Contrast Sensitivity; logcs: log of CS; ET peak: epithelial thickness changes at the corneal apex; ET center: epithelial thickness changes at the center of the cornea

Table 3: Correlation between the median values of variance of different variables for OD.

Discussion

In this study we investigated the change in the thickness of the corneal epithelium at ETcenter and ETpeak in relation to LOAs, HOAs, CS and CDVA after PRK. Our research showed that ET increased after PRK and this appeared to be related to increased LOAs (Z11) and increased HOAs (Z31, Z40 and Z42). It also seems that the increase in ET peak is related to the decrease in LOAs (Z00, Z02) and the decrease in CDVA. Furthermore, we demonstrated that the ETcenter increased after PRK and this appeared to be associated with an increase in ETpeak, CS and HOAs (Z31, Z40 and Z42).

Also, the decrease in LAOs (Z00, Z02) and the decrease in CDVA appeared to be related to the increase in ETcenter. We also showed that an increase in CDVA is associated with an increase in LOAs (Z00, Z02). The increase in CDVA was related to the decrease in CS, ET peak, ET center and HOAs (Z40). Finally, an increase in CS is associated with a decrease in HOAs (Z33). It is possible that this is due to the fact that in PRK we have an epithelium removed and during its regeneration we have different epithelial cell quality. With differences which are in the quality of the new epithelial cells, or there are differences in the clarity of the specific cells or differences in the shape and size of the new cells and this regeneration of the epithelial cells is responsible for the change of the parameters to be studied.

Studies have shown that after PRK, ocular aberrations increase and visual output of the treated eye decreases [6,7]. Seiler T, et al., report that HOAs increase during epithelial remodeling after PRK surgery [6]. Ivarsen, et al., in their study found that one year after PRK changes in the corneal epithelium may be associated with a large increase in spherical aberration [8]. According to Latifi, et al., ET increased one year after PRK [9]. According to Juhasz, et al., and Hashemi, et al., PRK induced an increase in HOAs [10,11]. Also in their study, Ghanavati, et al., demonstrated that after PRK, HOAs increased and CS improved [12]. In addition, Hosseini, et al., found in their study that HOAs increased after PRK [13].

According to Sajjadi, et al., PRK-induced global and HOAs [14]. Wu, et al., showed that HOAs increased after PRK [15]. All of the above agree with the results of our study. Even Fahim, et al., demonstrated that after PRK, comma and trefoil evaluation showed no significant difference between preoperative and postoperative values, but spherical aberration (Z40) increased one year after surgery [16]. Our findings agree with the increase in spherical aberration and deflection after PRK, but we found, as mentioned above, statistically significant differences before and after PRK surgery and in other HOAs and LOAs. In their study Guneri Beser, et al., showed that HOAs during the first postoperative year were normal when the pupil diameter was 3 mm.

However, the aberrations increased when the pupil diameter was 6 mm [17]. One of the limitations of this study was the small sample that was studied. Another limitation is follow-up time. It would be important to study the epithelial change and its relationship with the other parameters over a longer period.

Conclusion

In conclusion, after a PRK procedure, the change in ET peak and ET center was related to the change in the CDVA, but this change in thickness also affects and was associated with the changes in the LOAs and HOAs due to the change in shape and of the number of new cells during the regeneration of the epithelium. Also, the change in CDVA was associated with CS, LOAs and HOAs which over time become normal. Finally, it was shown that the change in the CS is related to the change in the ET center which is in front of the pupil. Every change in the ET center has as a consequence the change in the CS. What we already know about PRK is that the change in corneal shape results in changes in CDVA, CS and also HOAs. This work adds that the change in ETpeak and ETcenter is directly related to LOAs. An increase in ETpeak and ETcenter were observed which was inversely proportional to LOAs except Z11 after PRK. Also the change in corneal epithelial thickness was related to CS after PRK. CDVA was finally associated with CS as well as change in ETpeak and ETcenter of the cornea after PRK.

Conflict of Interest

The authors have no conflict of interest to declare.

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