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Original article

Longitudinal Analysis of Corneal Epithelial Thickness after Cataract Surgery Using Anterior Segment OCT

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Abstract

Background: The corneal epithelium plays a vital function in optics of eye. It influences tear film stability and maintains corneal function. topographic corneal epithelial thickness (CET) profile has been utilized in evaluation of corneal diseases such as corneal dystrophy and dryness. **Purpose:** To map the total changes of corneal and epithelial layer thickness following cataract surgery using a spectral domain anterior segment optical coherence tomography AS-OCT. M**aterials and Methods:** This prospective observational case series was conducted on 60 patients who made phacoemulsification. All patients were imaged preoperatively and up to one month postoperatively with AS-OCT (Optvue-2800 Bayview Drive Fremont, CA 94538, USA). Corneal pachymetry and CET maps were analyzed and correlated with phacoemulsification time and break up time (BUT). **Results:** 60 eyes of 60 patients, aged above 20 years (S.D=10.43 years); they were imaged postoperatively. UCVA and BCVA improved after one week and one month postoperatively respectively (p <0.001). For BUT the mean was 9 seconds after one day and 14 seconds after one month ($p1$=$p2$=.001). There are no significant changes in epithelial thickness map post-operatively. Regarding CCT, an initial significant increase was observed, then returned to pre-operative values. Compared to pre-operative, there was significant increase in CCT in 1st and 2nd visits $p\leq$0.001with pre-operative median 519µm. We also found significant regional positive correlation between the phacoemulsification time and TCT (Total corneal Thickness) during 1st follow up visit and no correlation with BUT was observed. **Conclusion:** We reported no change in CET after phacoemulsification. CCT increased initially and correlated with phacoemulsification time.

Keywords: Corneal thickness; epithelial thickness; Break up time; phacoemulsification time.

Introduction

The corneal epithelium plays an important role in the optics of the eye. It maintains the corneal integrity and function and affects the tear film stability [(1)]. The alterations of corneal epithelial thickness (CET) are found in many ocular conditions such as contact lens wearing [(2)], dry eye [(3)] and keratoconus [(4)].

Despite the fact that cataract surgery is well known to restore visual function, it can also induce traumatic damage to corneal epithelium [(5)] and to corneal endothelium with subsequent corneal edema [(6)].

Significant changes in epithelial thickness have been correlated with corneal instability [(7)]. For example, many patients who have undergone cataract surgery have complained of dry eye symptoms postoperatively due to corneal epithelial damage [(8)].

Also, knowledge of the topographic CET profile has been applied in clinical evaluation of various corneal disorders such as corneal dystrophies and in pre-operative refractive surgery evaluation [(9)]. One of the most recent applications of anterior segment optical coherence tomography (AS-OCT) is in vivo epithelial layer three dimensional thickness mapping such as keratoconus, post LASIK ectasia,[(10)] and pterygium [(11)] , OSSN(ocular surface squamous neoplasia) [(12)] corneal dystrophies [(13)]. After cataract surgery, four reports[(14-17)] had described changes in CET [(14,15,16,17)] .They reported initial significant increase in the CCT results just after the cataract surgery then returned to normal in the last visit post operatively.

The aim of this study was to describe the early tomographic changes of the CET after phacoemulsification surgery using AS-OCT.

Materials and Methods

This prospective observational case series was conducted on 60 patients aged above 20 years. Both genders were included. Complaining of diminution of vision and diagnosed with cataract undergone uneventful phacoemulsification. The study was approved by Institutional Review Board of Benha University (Ms 35-8-2021) and strictly followed the tenets of the Declaration of Helsinki. All patients signed a written informed consent before being enrolled. Patients were recruited during the period between Jun 2021 and April 2022 from outpatient clinic at Benha University Hospital. Exclusion criteria were age <20, ocular pathology like glaucoma, retinal diseases, patients with inflammatory eye diseases & systemic medications or illness that could affect the ocular surface.

All patients were subjected to full history taking past medical history.

Also, full ophthalmological evaluation, including assessment of visual acuity, best corrected visual acuity using Snellen chart, assessment of dryness by BUT (break up time) test, Examination of anterior segment by slit lamp as conducted during patient visits.

Cataract surgery was performed using Signature phaco machine (Abbott Medical Optics Inc.1700E St Andre Place, CA 92705,USA) after using proper anesthesia. Phacoemulsification time was recorded for each eye.

After phaco surgery, all patients were treated with systemic antibiotic (Ciprofloxacin 750 mg) twice daily for one-week, topical antibiotic (Moxifloxacin 0.5%) five times daily for one week and topical steroids (Prednisolone acetate 1%) five times daily for a week then tapered.

Post-operative, patients were followed-up routinely and reassessed for imaging at 1 day and one-month post-operative.

Epithelial and total corneal thickness mapping were generated by Spectral Domain anterior segment OCT (Optvue-2800 Bayview Drive Fremont, CA 94538, USA). The acquisition settings were L-Cam lens, 8 meridional B-scans per acquisition, 1,024 A-scans each with a 5-µm axial resolution, acquired in approximately less than a second. These eight radial meridional scans were employed by the system software to interpolate the three-dimensional thickness maps [(7)]**.** All data were collected from non-dilated eyes prior to phacoemulsification, then 1 day and 1 month after the procedure.

The image acquisition was similar to posterior segment imaging in that the patient was setting upright and no topical anesthesia was required. A wide palpebral fissure was required to fully image the anterior segment, and the patient was asked to focus on the internal fixation target at which point the images were obtained. All patients were imaged by the same trained investigator. We always tried to center the image capture on corneal vertex, however if the scan was tilted or decentered and the image quality was poor, a second trial was performed. Only images with quality higher than seven were evaluated.

Statistical Analysis:

The results were analyzed using Statistical package for the social sciences (SPSS), (version 19.0 for Windows, SPSS, Armonk, NY). Normally distributed continuous data were expressed as mean ± standard deviation (SD) while not normally distributed continuous data were expressed as median (range). Categorical data were expressed as percentage. T-test was used to evaluate normally distributed variables while not-normally distributed variables were analyzed using Mann-Whitney U test. Chi-square test was used to compare between qualitative variables. Paired samples T-test was used to compare the repeated measures of the tested parameters at each time point. Spearman rank was used for detection of the correlations. Results were considered statistically significant at a *p*-value less than 0.05.

Results:

Our study included 60 pseudophakic eyes of 60 patients who had underwent uneventful phacoemulsification surgery. The mean age (SD) was 60.28± 10.4 (range 35 – 80 years), with a 61.7% (n= 37) of patients were females. Phacoemulsification power time ranged from 8 to 55 seconds, with a mean of 18.3 seconds. Patients' demographics are summarized in table (1)

Postoperatively, the UCVA and BCVA significantly improved at the one week postoperative and after one month (p <0.001) (Table 2).

Regarding the BUT, initial significant drop was observed at one week compared to the preoperative one, then it has recovered by one month postoperatively (p<0.001) (**Figure 1).**

Regarding the epithelial thickness changes there were no significant changes in the epithelial thickness map post operatively (**Figure, 2).**

Compared to pre-operative, there was statically significant increase in CCT (central corneal thickness) in the 1st and 2nd visits $p\leq$0.001with pre-operative median 519µm. However, there was no significant

change between the 1st and 2nd visits **(Figure, 3).**

There was significant correlation between phacoemulsification time and corneal thickness map but there were no significant correlations observed between it and other study parameters (Table, 3).

Table (1): The demographics and the preoperative ocular features of the included patients.

	N=60	**%**
Sex:		
Female	37	61.7%
Male	23	38.3%
Age (year):		
Mean ± SD	60.28 ± 10.43	
Range	35 – 80	
Cataract density grade[10] :		
N1	13	21.7%
N2	23	38.3%
N3	10	16.7%
NS	2	3.3%
Intumescent	6	10%
AC	25	41.7%
PSC	37	61.7%
PC	14	23.3%
Brown	7	11.7%

*N (Nuclear); *AC (Anterior cortical); *PSC (Posterior subscapular cataract); *PC (Posterior cortical)

Table (2) Changes in UCVA and BCVA among the studied patients postoperatively as compared to preoperative value:

		Median	**IQR**	***p*1**	***p*2**
UCVA	Preoperatively	0.03	0.05 – 0.17		
	One week postoperatively	0.3	0.1 – 0.33	<0.001**	
	One month postoperatively	0.4	0.3 – 0.5	<0.001**	<0.001**
	p	<0.001**			
BCVA	Preoperatively	0.2	0.15 – 0.3		
	One week postoperatively	0.3	0.15 – 0.4	<0.001**	
	One month postoperatively	0.7	0.4 – 0.8	<0.001**	<0.001**

*p*1 difference between preoperative value and each other postoperative visit *p*2 difference between one day and one month postoperatively *p* for Wilcoxon signed rank test IQR interquartile range **$p \leq 0.001$ is statistically highly significant.

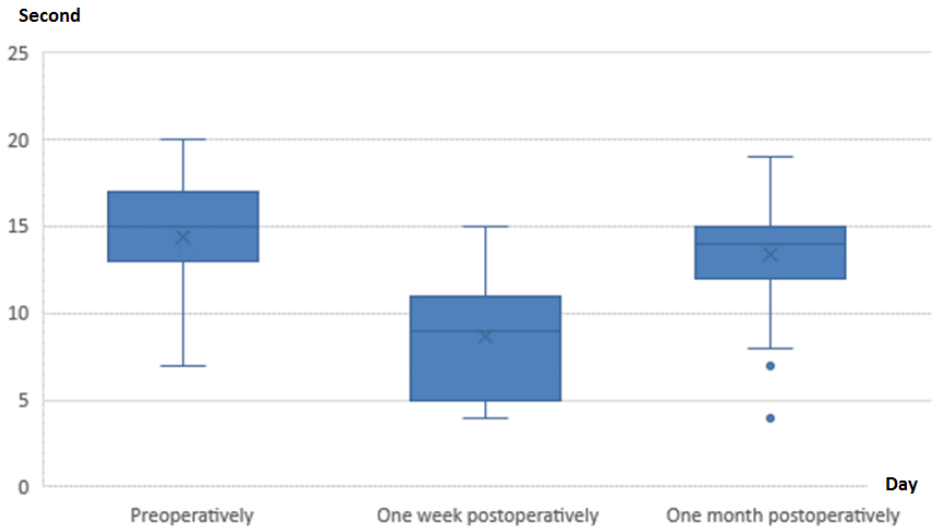

Figure (1) Boxplot showing Changes in BUT (Break up Time) among the studied patients postoperatively as compared to preoperative value

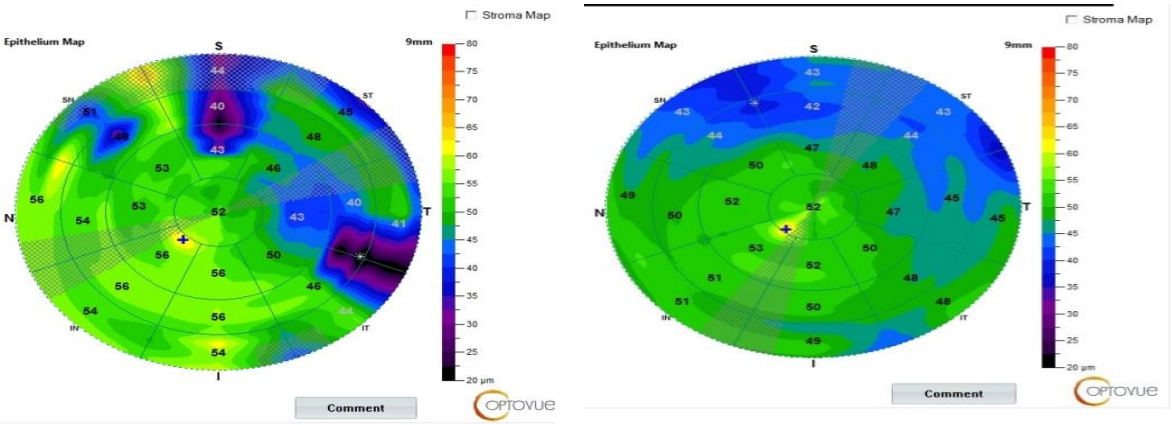

Figure (2):

(a) Showing epithelial thickness map of patient preoperative.

(b) Showing the epithelial thickness map of the previous patient one month post-operative.

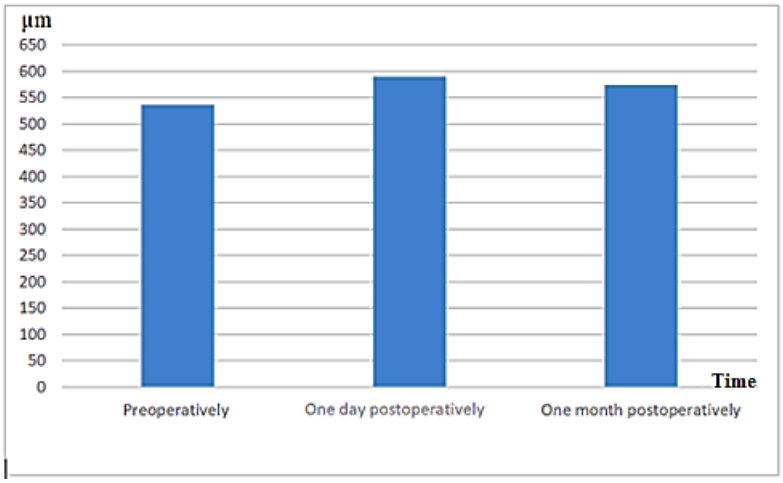

Figure (3) Bar chart showing change in Central corneal thickness among studied cases

Table (3) Correlation between phacoemulsification time and percent change in the corneal thickness after one month

	R	*p*
Superior corneal regional thickness	0.302	0.019*
Inferior corneal regional thickness	0.259	0.046*
Nasal corneal regional thickness	0.275	0.033*

r =Spearman rank correlation coefficient *$p<0.05$ is statistically significant **$p\leq0.001$ is statistically highly significant

Discussion

Cataract surgery has been known to cause a permanent loss of endothelial cells in 8% to 10%, with subsequent corneal edema [(6)], and also can cause trauma to the corneal epithelium [(5)]. Significant changes in epithelial thickness have been correlated with corneal instability [(7)]. For example, dry eye symptoms had been attributed to changes in the epithelium after cataract surgery postoperatively [(8)].

Spectral-domain OCT (SD-OCT) has proven to be a better tool for examining the corneal epithelium than time-domain OCT, because of its better resolution and ability to solve the problem of artifacts associated with eye movement during examination due to its higher imaging speed. Multiple studies have proven its reliability and repeatability in measuring epithelial thickness [(15, 20)].

For example, OCT imaging can also monitor changes in corneal epithelial and stromal thickness after procedures such as collagen cross-linking used for the stabilization in patients with keratoconus and may have a role in evaluating the demarcation line which correlates to the effective depth of the treatment [(10, 21)].

Moreover, Radwan et al investigated 100 eyes of 50 patients to assess the epithelial changes by anterior segment OCT and found that Epithelial thickness reached approximately the preoperative thickness at 2 months after PRK but there was statistically significant increase up to 3 months [(18)].

To the best of our knowledge, there is a lack of studies that discussed the change in

corneal and epithelial layer thickness changes following cataract surgery using a spectral domain anterior segment OCT. We aimed to describe the changes in corneal epithelial thickness using OCT.

In our study we did observe no significant tomographic changes in CET maps after phacoemulsification surgery. However, we reported a statistically significant increase in CCT one day post-operatively, without clinical corneal edema that was normalized during the last visit. We also found significant regional positive correlation between the phacoemulsification time and TCT (Total corneal Thickness).

In agreement with our results, [19] one study investigated 31 eyes of 29 patients underwent AS-OCT scans. All four quadrants were taken preoperatively and at 1-week, 1-month, 3-month, 6-month, and 1-year postoperative time points and found a significant improvement in the epithelial thickness and reflectivity of the cornea in eyes undergoing SLET and a significant correlation was found between the final visual acuity and the total corneal thickness [19].

Regarding postoperative changes in CCT, multiple studies [15-17] reported initial significant increase in the CCT in agreement with our results.

Regarding the regional changes in epithelial thickness, a previous study [16] investigated twenty patients with a senile cataract; they underwent coaxial phacoemulsification through a 2.75-mm-wide corneal incision created at 180° in a prospective cohort pilot study and reported no significant changes in epithelial thickness similar to our findings.

In contrast with our results, two studies [15-17], reported a transient increase in epithelial thickness. This contra verse might be explained by differences in imaging device, sample size, time of imaging and also follow up duration[7].

Our study has a few limitations. First, our results should be interpreted cautiously owing to the relatively small sample size and short follow up duration. Second, the incision area was not included in our map. Finally, patients with different ocular surface diseases were not included. Future prospective multicenter studies with larger sample size and longer follow up period are required to replicate our findings. Additionally, various ocular surface diseases should be included to test if the changes in the corneal pachymetry depend in part on the corneal health status.

Conclusion:

We reported a transient significant increase in CCT; however, there was no significant change in the regional epithelial thickness after uneventful phacoemulsification. ASOCT provides a reliable objective measure of these changes and can be used to monitor the outcomes in these eyes postoperatively.

Abbreviations

AC: Anterior cortical; BCVA: Best-corrected visual acuity; BUT: Break up time; CCT: Central corneal thickness; CF: Counting finger; HM: Hand motion; N: Nuclear; PC: Posterior cortical; PSC: Posterior subscapular cataract; UCVA: Un-corrected visual acuity; CCT: Central corneal thickness; CET: Central epithelial thickness; TCT; Total corneal thickness.

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