Original Article

Outcomes of phacoemulsification on the corneal endothelium in diabetic versus non-diabetic patients: A prospective non-randomized controlled interventional study

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ABSTRACT

Background: Cataract surgery in patients with diabetes is indicated either to improve visual acuity or to allow assessment and treatment of fundus changes. We aimed to document the effects of phacoemulsification on the corneal endothelium in patients with or without diabetes.

Methods: This comparative, prospective, non-randomized controlled interventional study was conducted in patients with visually significant immature senile cataracts in the ophthalmology department at Sohag University Hospital between January 2018 and December 2020. The following data were recorded: corrected distance visual acuity, keratometry readings, refraction, slit lamp examination results, and biometry data. Changes in corneal parameters were documented preoperatively and at 1, 3, and 6 months postoperatively using specular microscopy.

Results: Sixty-four eyes of 64 patients with visually significant senile cataracts were included (32 eyes in the diabetic group and 32 eyes in the non-diabetic control group). We found greater mean endothelial cell loss in the non-diabetic group (179 cells/mm^2; 6.4%) than in the diabetic group (134 cells/mm^2; 4.8%) at 3 months postoperatively, yet the difference was not significant. The difference could be explained by the higher mean cumulative dissipated energy (CDE) used in the non-diabetic group (5.37 J) than in the diabetic group (4.68 J), although the difference was also not significant. Moreover, we found significantly higher coefficient of variation (CV) in the non-diabetic group than in the diabetic group at 1, 3, and 6 months postoperatively (P = 0.03, P = 0.02, and P = 0.008, respectively).

Conclusions: Endothelial cell density was directly related to the CDE of phacoemulsification and not to diabetes. CV was significantly higher in the non-diabetic group than in the diabetic group. Future studies with a larger sample size, longer follow-up, and more diabetic subgroups with different levels of glycemic control are warranted to verify our conclusions.

KEY WORDS

phacoemulsification, intraocular, cumulative dissipated energy, cataract surgery, diabetes mellitus, corneal endothelium, diabetic, non-diabetic, specular microscopy, endothelial cell density, coefficient of variation, central corneal thickness

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INTRODUCTION

Cataract surgery with phacoemulsification is one of the most common surgical procedures performed nowadays. Compared to non-diabetic patients, patients with diabetes have an increased risk of developing cataracts [1, 2]. Cataract surgery in patients with diabetes is indicated not only to improve visual acuity but also to allow assessment and treatment of fundus changes [3].

Good vision after phacoemulsification requires a clear cornea. The corneal endothelium plays an important role in keeping the cornea clear via the endothelial pump mechanism. However, phacoemulsification may damage the corneal endothelium[4]. Morphologically abnormal endothelium has been observed in patients with diabetes. Patients with diabetes undergoing phacoemulsification are vulnerable to greater endothelial damage, and their visual acuity may drop despite good glycemic control [5]. Endothelial cell density (ECD) is lower in diabetic patients than in non-diabetic patients, and is inversely correlated with the duration of diabetes and hemoglobin A1c (HbA1c) levels [6, 7].

One study reported a greater loss in ECD following phacoemulsification in diabetic versus non-diabetic patients [8]. In contrast, endothelial cell loss following phacoemulsification is similar in diabetic and non-diabetic patients. However, a significant increase in the coefficient of variation (CV) and central corneal thickness (CCT), as well as a significant decrease in hexagonality have been documented in diabetic patients after phacoemulsification [9]. Due to the lack of consensus in the literature concerning the impact of phacoemulsification on corneal parameters in patients with diabetes, further studies are needed.

To document the effects of phacoemulsification and its potential hazards on the corneal endothelium in diabetic versus non-diabetic patients, we conducted a comparative, prospective study.

METHODS

This comparative, prospective, non-randomized controlled interventional study was approved by the Institutional Review Board (IRB) of the Faculty of Medicine, Sohag University, Egypt. In addition, it was registered at the Pan African Clinical Trial Registry (PACTR201804003056259) and adhered to the tenets of the Declaration of Helsinki. All surgeries were performed by a single surgeon (A.M.) at the ophthalmology department of Sohag University Hospital between January 2018 and December 2020.

The study included 64 eyes of 64 patients with visually significant senile cataracts. The study eyes were divided into two groups: Group A (control, non-diabetic group), comprising 32 eyes of 32 patients who were non-diabetic and had visually significant cataracts; and Group B (experimental, diabetic group), comprising 32 eyes of 32 patients with type 2 diabetes mellitus (T2 DM), no diabetic retinopathy, and visually significant cataracts. The nature of both diseases (senile cataracts and diabetes mellitus), treatment modality options, and potential intraoperative and postoperative consequences were explained carefully to all patients, who signed an informed consent form prior to surgery. All participants underwent a complete ophthalmic examination, and preoperative and postoperative measurements of ECD, CV, CCT, hexagonality, and minimal, maximal, and average cell sizes at 1, 3, and 6 months postoperatively.

The inclusion criteria for Group A were as follows: senile nuclear cataracts of nuclear grades NI and NII according to the Lens Opacities Classification System (LOCUS) III [10], no diabetes, normal fundus examinations, and intraocular pressure (IOP) within the normal range. The inclusion criteria for Group B were as follows: senile nuclear cataracts of nuclear grades NI and NII according to LOCUS III, age 50 to 70 years, well-documented T2 DM with a duration of ≥ 5 years, good glycemic control (glycosylated HbA1c < 7%) with oral hypoglycemic drugs, normal fundus examinations, and IOP within the normal range. We excluded patients with corneal pathology or low endothelial cell count (< 2000 cells/mm^2), poor pupillary dilatation, pseudo-exfoliation syndrome, high IOP, glaucomatous optic neuropathy, a previous history of ocular trauma or uveitis, previous eye surgery, current or previous macular edema, maculopathy or retinopathy, and cataract density interfered with preoperative ocular coherence tomography (OCT) imaging.

Specular microscopy was performed using an SP-1P device (Topcon Medical Systems, Inc., Oakland, NJ, USA) to measure the following parameters: ECD, CV, CCT, hexagonality, and minimal, maximal, and average cell sizes. Afterwards, all patients underwent cataract surgery using a phaco machine with the Infiniti Vision System plus OZil coupled with IP software (Alcon Laboratories Inc., Fort Worth, TX, USA). To obtain adequate pupillary dilation under topical anesthesia (benoxinate hydrochloride eye drops 0.4%; EPICO, 10th of Ramadan City, Egypt), cyclopentolate hydrochloride 50 mg + phenylephrine hydrochloride 500 mg eye drops (Cyclophrine eye drops; Kahira Pharm, Cairo, Egypt) was instilled into

the eye every 10 min for 30 min. Subsequently, the retrobulbar block was supplemented with facial nerve block anesthesia using lidocaine 2% sodium hyaluronate (Xylocaine; AstraZeneca, Cambridge, UK). Periorbital, forehead, and cheek skin was disinfected with 10% povidone-iodine (Betadine, Antiseptic Solution; Nile Company for Pharmaceuticals and Chemical Industries, Cairo, Egypt) immediately before surgery at the side of the operation table. Furthermore, half-strength (5%) povidone-iodine was instilled into the surgical eye immediately before surgery, and a disposable eye drape with a fluid collection bag (Freedom Ophthalmic Pvt. Ltd., Tamil Nadu, India) was placed over the open eye. The eyelids were kept open using an eye speculum.

We intended to perform a typical tri-planar wound to promote incision self-sealing. Two paracentesis incisions were made using a 20-gauge MVR knife (Alcon Laboratories Inc., Fort Worth, TX, USA), followed by a clear corneal incision using a dual-bevel 2.2-mm angled slit knife (Intrepid ClearCut HP2; Alcon Laboratories, Inc., Fort Worth, TX, USA).

Air was injected into the anterior chamber (AC) via the paracentesis incision followed by injection of the trypan blue ophthalmic solution (0.6 mg/mL) (Optiblu, Ophtechnics Unlimited, Haryana, India) to stain the anterior capsule. The residual dye was washed out by injecting compound sodium lactate solution (Ringer's lactate solution for intravenous infusion; Allmed Middle East Co., Giza, Egypt) into the AC. Subsequently, AC was formed by injecting a cohesive OVD (1.4% sodium hyaluronate ophthalmic solution; Optiflex, Moss Vision Inc. Ltd., London, UK). To perform continuous curvilinear capsulorhexis, an angular tab in the anterior capsule was made, then pulled in a curvilinear fashion, and the continuous tear proceeded clockwise by grasping the tearing edge with the capsulorhexis forceps (to control the vector of the tear); finally, a regular circular opening was formed. The next steps were cortical cleaving hydrodissection and OVD-assisted hydrodissection.

We planned to fix the intraoperative phacoemulsification settings. Phaco 1 parameters (sculpting) were set as follows: linear torsional amplitude, 100; phaco power, 0%; vacuum, 95 mmHg; bottle height, 98 cm; and aspiration flow rate, 23 mL/min. Phaco 2 parameters were set as follows: linear torsional amplitude, 95; phaco power, 0%; vacuum, 400 mmHg; bottle height, 95 cm; aspiration flow rate, 25 mL/min; dynamic rise, -2; and intelligent phaco, on. The epinucleus parameters were set as follows: linear torsional amplitude, 25; phaco power, 0%; vacuum, 330 mmHg; bottle height, 95 cm; aspiration flow rate, 24 mL/min; dynamic rise, 0; and intelligent-phaco, off. The cortex parameters were set as follows: vacuum, 380 mmHg; and aspiration flow rate, 30 mL/min.

Phacoemulsification was performed using the stop-and-chop technique. Automated irrigation aspiration of the cortical matter was then performed. Methyl cellulose was injected into the capsular bag, and AC was formed immediately before implantation of a foldable single-piece hydrophilic silicon intraocular lens with aspheric optics (UFold; Action Medical Pvt. Ltd., Maharashtra, India). The incisions were closed by hydration using Ringer's lactate solution. Finally, moxifloxacin ophthalmic solution 0.5% (VIGAMOX; Alcon Laboratories, Inc., Fort Worth, TX) and prednisolone acetate 1% ophthalmic suspension (Econopred Plus; Alcon Laboratories Inc., Fort Worth, TX, USA) were instilled, followed by eye patching. Finally, the cumulative dissipated energy (CDE) used in each case was recorded.

Data were analyzed using Stata (version 14.2; StataCorp). Quantitative data are represented as the mean and standard deviation (SD) and/or the median and range. Student's t-test was used to compare the means of two groups, and analysis of variance (ANOVA) was used for comparison of three or more means. For non-normally distributed data, the Mann–Whitney test was used to compare the means of two groups, and the Kruskal–Wallis test was used to compare three or more means. Qualitative data are presented as numbers and percentages and compared using either the chi-square test or Fisher's exact test. Comparison between preoperative and postoperative follow-up data at 1, 3, and 6 months was performed using repeated measures ANOVA. Mauchly's test of sphericity was used to examine sphericity. Bonferroni's post-hoc test was used to examine the differences at each time point. Spearman's rank order correlation coefficient was used because the data were not normally distributed. Statistical significance was set at $P < 0.05$.

RESULTS

The study included 64 eyes of 64 patients (one eye per patient), 33 (51.6%) of whom were men. The mean age ± SD was 59.59 ± 5.20 years in Group A and 58.13 ± 3.88 years in Group B. The preoperative baseline values were comparable between the two groups (Table 1).

Table 1. Characteristics of the study participants

Variable	Group A (n = 32 eyes)	Group B (n = 32 eyes)	*P- value*
Age, years			0.21
Mean ± SD, Median (Range)	59.59 ± 5.20, 60 (50 to 67)	58.13 ± 3.88, 57 (52 to 65)	
Sex			0.80
Men, n (%)	16 (50.00)	17 (53.13)	
Women, n (%)	16 (50.00)	15 (46.88)	
Cataract type			0.80
NI, n (%)	18 (56.25)	19 (59.38)	
NII, n (%)	14 (43.75)	13 (40.63)	

Abbreviations: n, number; %, percentage; NI, nuclear senile cataract grade NI hardness; NII, nuclear senile cataract grade NII hardness; SD, standard deviation. Note: Group A, non-diabetic patients; Group B, diabetic patients.

Table 2. Comparative analysis of central corneal thickness and endothelial cell parameters using specular microscopy

Variable	Group A Mean ± SD, Median (Range)	Group B Mean ± SD, Median (Range)	*P- value*
CCT (µm)			
Preop	508.78 ± 24.78, 507 (453 to 555)	513.77 ± 29.68, 513 (438 to 554)	0.50
1 month postop	511.94 ± 27.46, 510.5 (457 to 565)	517.53 ± 28.22, 519.5 (456 to 551)	0.42
3 months postop	510.94 ± 26.59, 506 (460 to 563)	516.78 ± 27.04, 521 (454 to 553)	0.39
6 months postop	509 ± 26.56, 509 (460 to 567)	515.22 ± 30.36, 511.5 (451 to 569)	0.39
6 months postop - preop	0.22 ± 17.81, 0.5 (-52 to 39)	1.78 ± 12.28, -1 (-52 to 39)	0.85
ECD (cells/mm²)			
Preop	2799 ± 349.69, 2799 (2137 to 3503)	2755.38 ± 333.27, 2737 (2207 to 3398)	0.61
1 month postop	2578.75 ± 360.39, 2571 (1816 to 3374)	2554.38 ± 340.49, 2591 (2007 to 3155)	0.78
3 months postop	2620.75 ± 360.23, 2660 (1850 to 3464)	2621.93 ± 318.54, 2635.5 (2203 to 3210)	0.99
6 months postop	2654.19 ± 351.80, 2696.5 (1851 to 3476)	2648.63 ± 331.49, 2650 (2200 to 3285)	0.94
6 months postop - preop	-144.81 ± 144.58, -85 (-666 to [-7])	-106.75 ± 85.50, -107 (-310 to [-4])	0.51
CV (%)			
Preop	36.16 ± 4.21, 36 (30 to 44)	35.38 ± 4.56, 35.5 (26 to 41)	0.48
1 month postop	38.72 ± 4.62, 38.5 (28 to 48)	35.84 ± 5.44, 38 (24 to 42)	**0.03**
3 months postop	38.72 ± 4.62, 38.5 (28 to 48)	35.78 ± 5.42, 38 (24 to 42)	**0.02**
6 months postop	39.38 ± 4.36, 40.5 (31 to 47)	36.09 ± 5.16, 37 (24 to 47)	**0.008**
6 months postop - preop	3.22 ± 3.95, 2 (-3 to 13)	0.72 ± 3.45, 0 (-8 to 10)	**0.004**
Hexagonality (%)			
Preop	48.16 ± 6.93, 48 (30 to 67)	51.5 ± 8.08, 52.5 (37 to 65)	0.09
1 month postop	42.84 ± 9.59, 43.5 (19 to 58)	47.25 ± 10.36, 49 (21 to 64)	0.08
3 months postop	41.69 ± 10.11, 44 (18 to 62)	46.44 ± 8.77, 47 (32 to 63)	0.05
6 months postop	42.78 ± 9.10, 42 (26 to 66)	44.09 ± 12.67, 44 (15 to 65)	0.64
6 months postop - preop	-5.38 ± 10.2, -7 (-22 to 20)	-7.41 ± 10.14, -5 (-31 to 7)	0.70
Minimal cell size (µm²)			
Preop	122.66 ± 12.23, 118 (103 to 148)	125.63 ± 11.84, 124.5 (109 to 146)	0.33
1 month postop	130.72 ± 19.64, 126 (111 to 190)	150.96 ± 44.20, 131 (115 to 272)	**0.02**
3 months postop	126.88 ± 17.25, 123.5 (109 to 180)	133.06 ± 21.85, 127.5 (103 to 184)	0.21
6 months postop	124.78 ± 17.99, 117 (109 to 183)	135.16 ± 22.26, 134 (111 to 200)	**0.04**
6 months postop - preop	2.13 ± 19.73, -1 (-0.25 to 62)	9.53 ± 20.71, 7 (-12 to 71)	0.12
Maximal cell size (µm²)			
Preop	798.06 ± 147.35, 795 (554 to 1083)	821 ± 111.30, 797.5 (679 to 1050)	0.48
1 month postop	864.81 ± 195.27, 834 (554 to 1553)	825.94 ± 143.22, 822.5 (590 to 1105)	0.37
3 months postop	821.19 ± 173.41, 778 (566 to 1565)	819.09 ± 130.14, 793.5 (575 to 1084)	0.96
6 months postop	827.91 ± 187.24, 768.5 (528 to 1549)	789.19 ± 81.74, 778 (668 to 939)	0.29
6 months postop - preop	29.84 ± 136.333, 32 (-190 to 466)	-31.81 ± 103.92, -19 (-299 to 118)	0.14
Average cell size (µm²)			
Preop	362.72 ± 42, 357.5 (285 to 468)	368 ± 44.13, 365 (294 to 453)	0.64
1 month postop	394.44 ± 58.48, 389 (296 to 551)	394.47 ± 57.99, 385 (300 to 498)	0.37
3 months postop	385.5 ± 59.96, 376 (285 to 548)	380.66 ± 44.73, 378 (289 to 454)	0.96
6 months postop	380.97 ± 57.72, 369 (288 to 549)	378.41 ± 48.27, 375 (276 to 459)	0.29
6 months postop - preop	18.25 ± 28.39, 10.5 (-27 to 125)	10.40 ± 16.72, 8 (-27 to 125)	0.29

Abbreviations: preop, preoperative; postop, postoperative; µm, micrometer; cells/mm², number of cells per square millimeter; %, percentage; µm², square micrometers; CCT, central corneal thickness; ECD, endothelial cell density; CV, coefficient of variation. *P*-values were calculated using either Student's t-test for normally distributed data or the Mann–Whitney test for non-normally distributed data. *P*-value < 0.05 is shown in bold. Note: Group A, non-diabetic patients; Group B, diabetic patients.

Table 3. Comparative analysis of phaco parameters

Variable	Group A Mean ± SD, Median (Range)	Group B Mean ± SD, Median (Range)	*P- value*
CDE (J)	5.37 ± 3.54, 4.18 (0.86 to 16.85)	4.68 ± 2.99, 4.66 (0.76 to 9.86)	0.66
US total (torsional) time (s)	27.79 ± 16.72, 22.25 (2.7 to 75.7)	25.43 ± 12.81, 27.35 (7.2 to 45.7)	0.95
Estimated fluid used (cc)	96.44 ± 27.44, 92.5 (37 to 181)	110.69 ± 33.82, 107 (65 to 181)	0.15

Abbreviations: SD, standard deviation; CDE, cumulative dissipated energy (expressed in joules); J, joules; US, ultrasound; s, seconds; cc, cubic centimeter; r, correlation coefficient. Note: Group A, non-diabetic patients; Group B, diabetic patients.

Table 4. Comparative analysis of correlation coefficient (r)

Variables	Group A		Group B	
	r	*P- value*	r	*P- value*
CDE (J) and ECD (cells/mm²)	-0.49	**0.01**	-0.42	**0.02**
CDE (J) and CCT (µm)	+0.14	0.44	+0.43	**0.01**
US total (torsional) time (s) and ECD (cells/mm²)	-0.07	0.70	-0.12	0.50
US total (torsional) time (s) and CCT (µm)	+0.13	0.48	-0.20	0.27

Abbreviations: CDE, cumulative dissipated energy (expressed in joules); J, joules; ECD, endothelial cell density; cells/mm², number of cells per square millimeter; CCT, central corneal thickness; µm, micrometers; US, ultrasound; s, seconds; Group A, non-diabetic patients; Group B, diabetic patients. *P*-value < 0.05 is shown in bold. Note: Spearman's rank order correlation coefficient was used because the data were not normally distributed.

Table 2 shows a comparative analysis of CCT and endothelial cell parameters measured using specular microscopy in Group A versus Group B. We found no statistically significant differences between the two groups in the preoperative and postoperative mean values of any parameter, except significantly higher mean CV and smaller minimal cell size in non-diabetic compared with diabetic patients ($P = 0.008$ and $P = 0.04$ at 6 months postoperatively, respectively). In follow-up visits, non-diabetic patients had significantly higher CV values at 1, 3, and 6 months postoperatively than diabetic patients ($P = 0.03$, $P = 0.02$, and $P = 0.008$, respectively). Table 3 shows that phaco parameters were comparable between the two groups.

Table 4 shows the correlation coefficient (r) between the CDE, ECD, CCT, and ultrasound (US) total (torsional) time. We found a low negative linear relationship between CDE and ECD: as CDE increased, ECD decreased in both non-diabetic and diabetic patients (r = -0.49 and r = -0.42 with $P = 0.01$ and $P = 0.02$, respectively). We also found a mild positive linear relationship between CDE and CCT: as CDE increased, CCT also increased in diabetic patients (r = 0.43, $P = 0.01$).

DISCUSSION

This study included 64 eyes of 64 patients (32 diabetic and 32 non-diabetic patients) who underwent phacoemulsification and posterior chamber IOL implantation to treat visually significant nuclear senile cataracts. Sahu et al. [11] reported the results of phacoemulsification in 120 eyes of 120 patients (60 with diabetes and 60 without diabetes). Similar to our study, they included subjects with T2 DM, ages 50 to 70, and with a HbA1c level < 7%. However, their specular microscopy outcomes differed from those of the current study. At the 3-month postoperative visit, they documented a mean endothelial cell loss of 121 cells/mm² (4.52%) and 157 cells/mm² (5.95%) in the non-diabetic group versus the diabetic group ($P = 0.008$). In contrast, our study found greater mean endothelial cell loss in non-diabetic patients (179 cells/mm²; 6.4%) than in diabetic patients (134 cells/mm², 4.8%), although this difference was not significant. This difference between the two studies could be explained on the basis of the mean CDE used in each group. In the study by Sahu et al. [11], the mean CDE of non-diabetic patients (17.95 J) was lower than that of diabetic patients (18.97 J), but the difference was not significant. On the contrary, we used greater mean CDE in the non-diabetic group (5.37 J) than in the diabetic group (4.68 J), yet again with no significant difference. Furthermore, the overall mean CDE was greater in both groups than in the current study, because they performed surgery for all grades of nuclear cataracts except grade 4, while we included only cataracts with grade NI and NII.

In addition, Sahu et al. [11] found significantly higher 3-month postoperative CV values (39.08% versus 36.20%, respectively) and greater postoperative CV differences (4.52% versus 3.16%, respectively) in non-diabetic than in diabetic patients. Similarly, we found greater postoperative CV differences in non-diabetic patients (2.56%) than in diabetic patients (0.4%); this difference remained significant until 6 months postoperatively (3.22% versus 0.72%, respectively). The higher CV in these two studies may indicate better cell response to healing,

repair, and restoring of endothelial cell function in non-diabetic versus diabetic patients. Furthermore, similar to our study, Sahu et al. [11] found lower postoperative mean hexagonality in both non-diabetic and diabetic patients; however, these postoperative differences were not significant.

Similar to our preoperative findings, Beato et al. [12] reported slightly higher hexagonality in diabetics than in non-diabetics, yet this difference was not significant in either study. In contrast to the results obtained by Beato et al. [12], the mean CV on preoperative specular microscopy was slightly higher in non-diabetic patients than in diabetic patients in the current study, yet with no statistical significance. Budiman found significantly higher mean hexagonality in patients with diabetes than in those without diabetes at 1 month after phacoemulsification [13]. This result was in contrast with ours, in which the difference was not significant at 1, 3, or 6 months postoperatively between the two groups.

Abdeen et al. [14] compared the change in mean ECD at 3 months after phacoemulsification in 23 eyes of patients with well-controlled T2 DM versus 23 eyes of non-diabetic participants. Their inclusion criteria were comparable to those of the current study, except that they operated grades NII and NIII senile nuclear cataracts, while we included only grade NI or NII to allow better visualization and good macular OCT imaging. Similar to our study, the mean preoperative ECD was lower in the diabetic group than in the non-diabetic group. However, in contrast to our results, the mean ECD loss in the diabetic group was significantly greater than that in the control group at 3 months postoperatively. ECD loss was 13% in patients with diabetes versus 9% in non-diabetic patients. They concluded that the cornea in patients with diabetes is more vulnerable to stress and trauma, which leads to more ECD loss despite good glycemic control. Contrary to Abdeen et al. [14], who found significant endothelial cell loss in the diabetic group at 2 weeks, 1 month, and 3 months postoperatively, we found no significant differences between the non-diabetic and diabetic group at 1, 3, and 6 months postoperatively. A possible reason for the difference between the two studies could be the greater CDE with prolonged phaco time for the harder nuclear cataracts graded as NII and NIII in the study by Abdeen et al. [14], while we had lower CDE with shorter phaco time for the less hard nuclear cataracts graded as NI or NII.

Hugod et al. [5] reported postoperative results in 30 patients with diabetes and 30 non-diabetic patients with a 3-month follow-up. Despite significant mean ECD loss and decrease in hexagonality in diabetic patients compared with controls, they found no significant change in CV or CCT. This is in contrast with our result, which revealed significantly higher CV values at 1, 3, and 6 months postoperatively in non-diabetic versus diabetic patients, yet no significant difference was found in ECD and hexagonality. In addition, Storr-Paulsen et al. [7], who compared 107 patients with T2 DM with 128 non-diabetic patients with no history of ocular surgery, reported a significant increase in CCT but no significant differences in ECD, hexagonality, or variation in CV. Similarly, preoperative examinations in our patients revealed no significant differences in ECD, hexagonality, and CV between the diabetic and non-diabetic groups. In contrast, we also found no significant difference in CCT between the two groups preoperatively.

Tang et al. [15] conducted a meta-analysis of 13 primary studies on corneal changes following phacoemulsification in diabetic versus non-diabetic patients. Their analysis of pooled data revealed a significant difference between the two groups in ECD and hexagonality at 1 day, 1 week, 1 month, and 3 months; in CCT at 1 month; and in CV at 1 week and 1 month after phacoemulsification. However, CCT at 1 day, 1 week, and 3 months or CV at 1 day and 3 months were not significantly different between the two groups. The authors concluded that the cornea in patients with diabetes might be more vulnerable to stress and trauma, leading to more morphological abnormalities and extended recovery time [15]. Similar to our study, Misra et al. [16] and Wang et al. [17] have documented 6-month postoperative changes in corneal parameters; those studies had the longest follow-up period among the included primary studies [15]. We found no statistically significant differences between the groups in the preoperative and postoperative mean values of all parameters, except for a significantly higher mean CV at 1, 3, and 6 months as well as smaller minimal cell size at 1 and 6 months postoperatively in non-diabetic patients compared with diabetic patients.

Despite being a prospective study with a well-matched control group and a long postoperative follow-up, our study is limited by its small sample size and narrow spectrum of T2 DM in terms of glycemic control level. Future studies with a larger sample size, longer follow-up, and more diabetic subgroups with different levels of glycemic control are needed to ascertain the relationship between postoperative changes in corneal parameters and various levels of glycemic control. The effect of glycemic control level on corneal parameters at different postoperative time points in a wide range of glycemic control levels could be an important question for future studies. Looking for a possible correlation between phacoemulsification and corneal parameters in these diabetic subgroups could be another interesting subject for research.

CONCLUSIONS

We found ECD as a sensitive parameter that was inversely related to the CDE of phacoemulsification but not to diabetes, as the non-diabetic group had a significant intraoperative endothelial cell loss that was associated with a relatively higher intraoperative CDE when compared to the diabetic group. In the non-diabetic group, the healthy postoperative corneal endothelium exhibited a better healing response to the surgical insult regarding endothelial cell polymegethism. We found significantly higher CV and smaller minimal cell size changes in the non-diabetic group than in the diabetic group. These outcomes may indicate the ability of the healthy corneal endothelium to rapidly and efficiently restore the function of the lost intraoperative endothelial cells by increasing cell polymegethism in non-diabetic patients.

ETHICAL DECLARATIONS

Ethical approval: This study was approved by the Institutional Review Board (IRB) of the Faculty of Medicine, Sohag University, Egypt. In addition, this study was registered at the Pan African Clinical Trial Registry (PACTR201804003056259) and adhered to the tenets of the Declaration of Helsinki.
Conflict of interest: None

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