Effect of phacoemulsification on corneal endothelium in type 1 and type 2 diabetes mellitus
Tarek Abdel Razik, Amr Said

Department of Ophthalmology, Faculty of Medicine, Alexandria University, Alexandria, Egypt
Correspondence to Amr Said, MD, PhD, Department of Ophthalmology, Faculty of Medicine, Alexandria University, Alexandria, Egypt. Tel: +20 102 353 2156.
E-Mail: docamro1@gmail.com
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Introduction
Phacoemulsification is one of the most commonly performed surgery with an estimated 19 million operations performed annually worldwide [1]. The WHO states that this number will increase to 32 million by 2020 [2] as the over-65-year-old population worldwide is expected to double between 2000 and 2020 [3]. One of the main concerns during phacoemulsification is the effect of ultrasound energy on corneal endothelium especially in the harder nucleus cases [4]. With modern phacosurgery, the use of more vacuum and less energy with application of torsional rather than longitudinal together with the advances in the field of ocular viscoelastic materials provided a less hazardous effect on various ocular structures, namely the endothelium [5–7]. However, endothelial cell loss is still a concern for cataract surgeons especially in cases with vulnerable endothelium as in the presence of corneal guttata and in diabetic patients [8,9]. The diabetic cornea suffers from endothelium cellular dysfunction and dysfunctional repair mechanisms due to hyperglycemia-induced increase in aldose reductase activity with expression matrix metalloproteinases [10]. Metalloproteinases can damage the basement membrane and limit cellular migration of the endothelium, resulting in poor healing. This makes the cornea of diabetic patients more vulnerable to stress and trauma than in nondiabetics [11].

Proved in some studies to affect more than 20% of diabetic patients, the effect of the type of diabetes, duration, and control on the outcome of cataract surgery becomes of paramount importance among cataract surgeons [12].

The aim of this study was to compare endothelial cell changes following straightforward phacoemulsification in diabetic patients with type 1 and 2 diabetes mellitus (DM).

Patients and methods
A retrospective analysis was conducted on records of patients operated by the same surgeon (T.A.R.) for cataract surgery and intraocular lens (IOL) implantation and having DM either of type 1 or type 2 during the period from January 2014 till January 2019 at Alex Eye Center, Alexandria,
Egypt. Written informed consent was obtained from each participant in concordance with Declaration of Helsinki. Ethics Committee at Faculty of Medicine, Alexandria University approved this study. All procedures performed in studies involving human participants were in accordance with the ethical standards of the research committee.

Cataract removal surgery was done for a total of 320 eyes of 400 patients after obtaining informed consent from the patients. Cases of macular scars and glaucoma were excluded from the study. Patients with poor glycemic control at the time of surgery (glycosylated hemoglobin > 7) were also excluded.

Preoperative examinations were conducted for cataract density, keratometry, axial lengths, posterior segment abnormalities, intraocular pressure, and systemic disorders. Baseline endothelial characteristics were evaluated using specular microscopy.

IOL power calculation was performed in all cases using optical biometry (IOL-master; Carl Zeiss, Germany) with theoretical formula SRK-T. Carl Zeiss Meditech Inc., Dublin, California, USA.

The patients were distributed into two groups. First group had type 1 DM while group 2 with type 2 DM.

Corneal incisions were created using a 2.4 mm keratome blade for the main incision placed in all cases on the steep topographic axis as determined using corneal topography and 1.2 mm blade for the side ports. The anterior chamber was filled with viscoelastic. Continuous curvilinear capsulorhexis was created with a capsulorhexis forceps. Lens segmentation was performed using a divide-and-conquer approach.

Infinity Phacoemulsification System (Alcon, USA) was used in all cases. Effective phaco time was calculated in each patient. Patients with intraoperative complications such as vitreous loss, dropped lens matter into the posterior segment, or lens capsule subluxation were excluded from the study. The procedure was followed by IOL implantation in the capsular bag after removal of the lens cortex: Tecnis-1 aspheric IOL (Advanced Medical Optics) using its injector provided by the company. Careful removal of viscoelastic material from the anterior chamber was carried out in all cases followed by careful stromal hydration of all corneal wound. Postoperative antibiotic and steroid eye drops were prescribed for 1 week followed which antibiotic eye drops were stopped, while gradual withdrawal of steroid eye drops was performed along 3 weeks.

All cases were followed after 1 day and then after 1 week, 1 month, and 3 months. Visual acuity and refraction were measured during all follow-up visits. Specular microscopy was performed during 1 and 3 months only. Mean absolute error (MAE) and manifest refraction spherical equivalent (MRSE) were calculated at both follow-up periods in each group.

Statistical analysis

The data were entered into an Excel spreadsheet (Microsoft Corp., Redmond, Washington, USA). It was converted into a spreadsheet for Statistical Package for Social Studies (SPSS, version 23 for Windows). SPSS for windows Version 19 (IBM/SPSS Inc., Chicago, Illinois, USA).

Quantitative data were described using range, mean, and SD. Comparison between different periods was assessed using paired *t* test for comparisons between the preoperative and postoperative data. To compare between both groups if they are normally distributed, independent sample *t* test was used. The Mann–Whitney *U* test was applied to assess the significance of such differences when parametric analysis was not possible (in values that are not normally distributed according to Kolmogorov–Smirnov test for normality of distribution).

Percentages of endothelial cell loss in both groups were calculated. *χ*² test was used to compare between both groups regarding different percentages. Differences were considered to be statistically significant when the associated *P* value was less than 0.05 at 95% confidence interval.

Results

The current study was a retrospective comparative analysis of the records of 400 eyes of 320 diabetic patients with visually significant cataract affecting the quality of life. Table 1 shows the demographic and preoperative characteristics of the included patients. There was no statistically significant difference between the two groups regarding preoperative characteristics. The two groups were highly comparable to each other regarding the mean age, axial length, manifest refraction, and preoperative endothelial cell count as measured using specular microscopy. None of the eyes reached 20/20 of corrected distance visual acuity (CDVA), and the worst CDVA was 20/125. Subgroup analysis of the right eye or the left eye alone did not show any different results.

Table 2 shows the visual acuity [uncorrected distance visual acuity (UDVA) and CDVA], endothelial cell count, and manifest refraction along the postoperative
follow-up period. There was a statistically significant difference between the two groups regarding the UDVA, CDVA, and endothelial cell count. Both were less in patients with type 1 DM. MAE and MRSE show no statistically significant differences between both groups. Using paired $t$ test to compare mean UDVA, CDVA, endothelial cell count, MAE, and MRSE at 1 and 3 months, there was no statistically significant difference. Endothelial cell count dropped with statistically significant difference in both groups at the first month of follow-up in comparison to the preoperative values with further drop at 3 months of follow-up that was not statistically significant. The mean CDVA at 1 and 3 months improved in comparison with preoperative levels for both groups.

### Discussion

Several studies have been conducted to evaluate the effect of various techniques of cataract surgery on the corneal endothelium. All these studies have shown a decline in the endothelial status after surgery [13,14]. However, there are only a few studies which have compared these changes in patients with diabetes. Al-Sharkawy had conducted a similar study on 100 eyes of 99 patients (49 with and 50 without type 2 diabetes) with senile cataract who underwent phacoemulsification with foldable IOL implantation. Specular microscopy was performed preoperatively, at 1 week and at 3 months postoperatively to evaluate endothelial cell density, coefficient of variation (CV), and central corneal thickness (CCT). Although no significant difference was found in ECL following phacoemulsification between the two groups, diabetic patients had a significantly greater increase in CV (polymegathism) and CCT compared with nondiabetic patients. Al-Sharkawy disagrees with our study in comparison between nondiabetic and diabetic groups in terms of the difference between preoperative and postoperative CCT but in terms of endothelial cell loss as it was significant in our study [15]. Wojciechowska et al. [16] found no statistically significant differences in corneal endothelial changes after extracapsular cataract extraction with posterior chamber IOL implantation between nondiabetic and diabetic patients. Lee et al. [17] investigated the differences in corneal endothelial cell morphology between diabetic patients who were divided by the degree of severity of diabetic retinopathy and normal patients after phacoemulsification with IOL implantation and concluded that corneal endothelial cell density decreased and the CV in cell size increased for high-risk proliferative diabetic retinopathy patients undergoing phacoemulsification, in contrast to normal persons at 6 months postoperatively. Although the exact explanation for the discrepancy between the results of the present study and others is difficult to determine, one possible reason may be that the diabetic conditions, particularly blood glucose levels and duration of disease, was different in the various studies.

Khan and colleagues had a similar study conducted on 66 cataract patients, out of which 33 patients were with
DM and 33 without DM (type 2). After phacoemulsification, all cases were followed up on first day, first week, 1 month, and 3 months; and UDVA, best-corrected visual acuity, corneal thickness, endothelial cell count, and morphometric analysis were recorded. At the end of 3 months, it was found that the mean endothelial cell loss in group A (diabetic) was 6.9±0.6% and in group B (control) was 2.4±0.3%. In Khan’s study the mean endothelial cell loss in diabetic patients is less than in our study; however, it was still statistically significant as in our study [18]. Our study has some limitations. Being retrospective in nature makes the study liable to be affected by confounding factors. Also, lack of control group of nondiabetic patients may be another source of criticism. No available data were found in the reports regarding other endothelial cell characters rather than cell count such as the percentage of hexagonal cells and CV.

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Data availability: ?data used to support the findings of this study are available from the corresponding author on request.

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Conflicts of interest
None declared.

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