Selected pre-operative and intraoperative factors affecting changes in corneal endothelial cell density three months after phacoemulsification at a private eye hospital in Nairobi, Kenya

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ABSTRACT

Objective: To evaluate selected patient factors that affect endothelial cell loss 3 months following phacoemulsification surgery.

Methods: This was a prospective cohort study carried out at a single center, Eagle Eye and Laser Center, Nairobi, Kenya that has a Tomey 3000 specular microscope. All patients undergoing phacoemulsification surgery during the study period were included. The collected data was entered into Microsoft Excel and analyzed using SPSS

Results: Average age was 65±12.327 with a M:F ratio of 1.2:1. Forty-one eyes of 33 patients were studied and showed an overall endothelial cell loss of 7.2%. Diabetes was associated with more endothelial cell loss while longer axial length was associated with less endothelial cell loss.

Conclusion: Phacoemulsification surgery is safe despite inevitable minimal loss in endothelial cells. Care should be taken when operating on diabetic patients due to their susceptibility to more cell loss.

Key words: Phacoemulsification, Endothelial cells, Corneal endothelial cell density, Anterior chamber depth, Axial length

INTRODUCTION

The endothelium is the inner most layer of the cornea and is composed of a single layer of polygonal cells that interdigitate and are of variable shape (polymorphism) and size (polymegathism)[1]. These cells are the anatomical and physiological interface between the aqueous humour and the corneal stroma and through ion channels are responsible for pumping out water from the stroma to maintain corneal clarity and thickness[2]. When there is endothelial injury from trauma or surgery, these cells are thought to migrate and change shape so as to fill the gap. ECD at birth is 5000 cells/mm^2 and declines physiologically to about 200-3000 cells.mm^2 in adults[3,4]. Corneal Endothelial Cell Density (ECD) of 450-800 cells/mm^2 is associated with corneal oedema and loss of corneal clarity hence reduced vision[5].

Globally, it is estimated that 94 million people are blind or visually impaired with the leading cause being cataracts[6]. A systematic review and meta-analysis of population-based eye health surveys between January 1980 to October 2018, found cataracts to be the common cause of blindness in people aged over 50 years old at about 15.2 million cases[7]. The prevalence of cataracts is expected to increase due to increased life expectancy.

Surgery is the mainstay treatment for cataracts and phacoemulsification is one of the current methods used in cataract extraction alongside Extracapsular Cataract Extraction (ECCE), with a comparatively smaller incision and injury area. A systematic review and meta-analysis showed that phacoemulsification has better visual outcomes and reduced complication rates compared to ECCE[8]. Phacoemulsification was first performed in Kenya in 1993, and is now the preferred surgical intervention for cataracts in several high-volume centers across the country[9].

Phacoemulsification utilizes ultrasonic energy, which are mechanical waves of more than 20kHz that causes thermal and mechanical damage to the corneal endothelium[10]. This is mainly due to the small confined space that is the anterior chamber in which the surgery is performed making it inevitable that there will be contact between the corneal endothelium and the instruments and fluid used[11]. Corneal endothelial Cell Loss (ECL) following phacoemulsification has been found to be between 5-19.2%[12,13].

Various patient factors affect the degree of corneal endothelial cell loss, such as age, diabetes status[12,14,15] cataract density, axial length and anterior chamber depth[16].

In Kenya, a study evaluating the effects of phacoemulsification on the cornea had not been carried out, despite its widespread use and increasing uptake, hence this study was carried out with the aim of evaluating these changes.

Broad objective: To assess corneal endothelial cell density changes 3 months after phacoemulsification.

Specific objective: To determine the change in corneal Endothelial Cell Density (ECD) associated with selected factors: age, diabetes status, axial length and anterior chamber depth.

MATERIALS AND METHODS

Study design: This prospective study was conducted at Eagle Eye Laser Center (EELC), a private eye hospital in Nairobi serving a diverse population within the city and beyond. All patients undergoing phacoemulsification between August 2018 to January 2019, and were followed up for three months until April 2020.

The center was chosen because of its availability and use of a specular microscope (Tomey- EM 3000, a non-contact specular microscope) that was used to check the corneal endothelial cell density of all patients about to undergo phacoemulsification. A specular microscope is the instrument used to measure corneal endothelial cell density by taking an image of reflected light from the optical interface between the aqueous humor and corneal endothelium. These images are then analyzed by the machine to give different characteristics such as number, density, shape and variation in size[11]. There are four main techniques used to determine endothelial cell density[17].

- Comparison method, whereby the patient's endothelium is compared to a known set of hexagon patterns.
- Frame method (fixed or variable)- where cells are counted within a rectangular or hexagonal frame.
- Corner to corner method- where cells' corners are counted.
- Center to center method- where the center of the cell is counted.

The Tomey 3000 specular microscope used in our study utilizes the fixed frame method of ECD calculation. A-scan by Alcon© was used to measure Anterior Chamber Depth (ACD) and Axial Length (AL).

During the study period at EELC all phaco surgeries were performed by two surgeons (HG and JN) on the same Alcon Accurus© phacoemulsifier; ECD and biometry recorded by one experienced technician and intraoperative data from the Alcon Accurus© captured by one experienced theatre nurse.

Ethical consideration: The study adhered to the tenets of the Helsinki Declaration. Before beginning, ethical approval was sought and granted by the Kenyatta National Hospital-University of Nairobi Ethics and Research Committee. Permission was sought and granted by the administration of EELC. Written and informed consent was obtained from each participant.

Inclusion criteria: All eyes undergoing phacoemulsification during the study period. The center lacked an anaesthesia machine at the time, hence only adults were included in the study

Exclusion criteria: Eyes with other ocular pathology such as trauma, inflammation or infection which would be possible cause of endothelial cell loss post-operatively were excluded. Any eyes that had intraoperative complications hence had a longer than was usual exposure to phacoemulsification energy and intra-operative fluids were also excluded. Eyes with ECD <2000 were also excluded because this would be considered low for an adult eye with increased risk of accelerated endothelial cell loss and delayed corneal recovery post-operatively[18]. The eyes in which no phaco power was used intraoperatively due to very soft lenses that didn't require it were also excluded because they did not have the exposure on interest to the study.

Data collection and analysis: To be included in the study, recruited patients were asked to sign informed consent. The principal investigator or research assistant then filled into a questionnaire their name, age, sex, ocular history and diabetic status (yes or no). ECD was then taken to be an average of two readings from the Tomey 300 specular microscope to enhance accuracy, Axial length and anterior chamber depth were taken from the biometry data. Intraoperatively, the phaco power was read from the Alcon Accurrus© phacoemulsifier. Three months post-operatively, the ECD was calculated as an average of two readings and also recorded in the patients' questionnaire. The collected data was then fed into Microsoft Excel 2019 and analyzed using SPSS version 25. Descriptive analysis was used to determine frequencies and proportions. ANOVA test was used to test variance and statistical significance was set at p-value of <0.05 and confidence interval was set at 95%.

RESULTS

Forty-one eligible consecutive eyes of 33 patients were included in the study following exclusion of 14 eyes. The 14 eyes were excluded for the following reasons:

- 5 eyes had no phaco power used intra-operatively
- 5 eyes had intra-operative complications
- 3 eyes had missing post-operative data; the patients were lost to follow up
- 1 eye developed post-operative uveitis.

The pre-operative demographics of the participants and intra-operative characteristics are in Table 1.

Table 1: Demographics and pre-operative patient characteristics

Characteristic	Study population	P-value
Age (Mean ±SD)	65.48 ±12.32	0.904
Gender (M:F)	18/15 (55%/45%)	
Laterality R:L	19/22 (46%/54%)	
Diabetes Y:N	8/25 (24%/76%)	
Axial Length (mm) Mean ±SD	23.76 ±1.14	0.258
Anterior chamber depth (mm) mean ±SD	3.70 ± 0.80	0.434
Overall pre-op corneal ECD (cells/mm^2) mean ± SD	2399 ± 196.19	
Mean corneal ECD in eyes of male vs female (n=23 vs 18)	2363 vs 2427	
Mean corneal ECD Right vs Left eye (n=19 vs 22)	2431 vs 2372	
Mean corneal ECD DM vs No DM	2477 vs 2382	
Mean corneal ECD Normal axial length ≤25mm (n=35) vs longer axial length >25mm (n=6)	2393 vs 2436	

Table 2: Post-operative corneal ECD measurements and changes in cells/mm^2

Characteristic	ECD in cells/mm^2	Change in ECD (%)	P-value
Post-op ECD at 3 months (cells/mm^2) mean ± SD	2227 ±192.41	-172 (7.2%)*	
Male vs female	2231 vs 2248	-132(5.6) vs -179 (7.4)	0.514
Right vs left eye	2271vs 2224	-160(6.6) vs -148(6.2)	0.340
DM vs non DM	2276 vs 2235	-171(7.0) vs -147(6.2)	0.870
Normal axial length (≤ 25mm) vs longer axial length (>25mm)	2204 vs 2364	-189 vs -72	

The change in ECD was calculated as the percentage of the difference between the pre-op and post-op ECD.

A multivariate analysis of age, diabetic status, axial length and anterior chamber depth had a p value of 0. 046.

DISCUSSION

This study found an overall endothelial cell loss of 7.2% which is in keeping with several studies[12,13,19], who found a range of loss of between 4-19 % in their studies. This value was calculated as a percentage of the difference between overall mean pre-op and post-op corneal ECD at 3 months.

This study found a slight male preponderance, similar to a study done by Khalid *et al*[11]. When eyes of males were compared to those of females, there was no statistically significant difference in loss of endothelial cells which was in keeping with findings by Mohan *et al*[20] and Mazhar *et al*[21] who had similar results. We further found an average age of 65 years in patients with cataracts who underwent phacoemulsification which is in keeping with other studies[11,22] which found that the prevalence cataracts is high among those over 50 years old in sub Saharan Africa. Age was however not found to be a statistically significant factor in endothelial cell loss such as found by *Dewan et al*[23]. Endothelial cell loss between right and left eyes was comparable and not statistically significant which could be explained by both surgeons being competent in their operative skills on operating either eye.

The diabetic patients had slightly more endothelial cell loss at the end of the 3 month follow up period, but this was not statistically significant. Our findings are in keeping with those of *Yang et al*[14] and *Tang et al*[15] in their systematic review and metanalysis of corneal endothelial changes after phacoemulsification in diabetic vs non-diabetic patients, whereby they found no statistically significant difference between the two groups at all time points. They then concluded that despite the greater loss and more in diabetic patients' corneas, there is recovery of these cells albeit delayed compared to non-diabetics. This could be explained by hyperglycemia causing more dysmorphological changes in the corneal endothelium, damage to the basement membrane, abnormal cell adhesion and limited cell migration[14,15].

According to studies by Bhardwaj *et al* [24] and Jing *et al*[25], the normal axial length is considered to be between 22-25mm. In our study, 35 eyes were found to be of normal axial length, while were found to be longer than 25mm. The endothelial cell loss in longer eyes was found to be less than in those with normal axial length. Longer axial lengths may be associated with deeper anterior chambers hence allowing more space and less contact with the endothelium, thus less cell loss as similarly shown by Walkow *et al*[26] and Bhardwaj *et al*[24]. However, on statistical analysis of axial length and anterior chamber depth these factors were not found to be significant. This was not similar to what was found by Khalid *et al*[11] who found significance in both of these factors. Our study had a significantly larger number of eyes with normal axial length compared to those with longer eyes, hence the statistical analysis may not be as applicable. However both *Hwang et al* [26] and *Cho et al*[16] found that ACD wasn't a significant factor in corneal endothelial cell loss which was more influenced by cataract density and corneal incisional tunnel length which we did not study.

Limitations: ECD readings were made only at the central cornea which does not factor in changes in peripheral areas of the cornea that are also likely affected by phacoemulsification whose incision and ultrasound energy are applied on the peripheral cornea. Cataract density wasn't graded pre-operatively and would have been compared to the change in endothelial cell density. Intraoperative factors such as corneal incision site and length were also not measured and compared in our study.

Recommendation: A randomized control study in a large volume center with clear grading of the cataracts pre-operatively and measurement of the incisional tunnel length to evaluate the impact of these factors.

CONCLUSION

Phacoemulsification is a safe procedure despite causing inevitable minimal loss of endothelial cells due to various patient and anatomical factors. However, the loss is well compensated for by 3 months postoperatively. Caution should be taken when operating on diabetic patients due to their increased susceptibility to endothelial cell loss.

Acknowledgment

Eagle Eye and Laser Center, Nairobi for providing the specular microscope.

Declaration

Funding: This work was not funded

Consent for publication: all authors have read and approved the final manuscript

Availability of data and materials: The data is available from the corresponding author upon reasonable request.

Competing interests: None to declare.

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