

Changes in central corneal thickness three months after cataract surgery using phacoemulsification

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Abstract

Introduction: The cornea is the most powerful refractive surface of the eye with the central cornea being pivotal to the visual axis, and hence visual acuity. Phacoemulsification is a method of cataract surgery that emits both thermal and ultrasonic energy which affects the cornea. Our study is to establish changes to the central corneal thickness (CCT) three months after surgery.

Objective: To establish the changes in CCT three months following phacoemulsification and the factors that influence these changes.

Materials and Methods: The study was a prospective case series carried out at the Eagle Eye and Laser Centre in Lavington, Nairobi. The recruitment of patients into the study was for 6 months between 1st August 2018 and 31st January 2019, and this was followed by a 3-month follow-up period until 30th April 2019. Eyes of patients who underwent phacoemulsification surgery were included. Eyes with pre-existing pathology, intra-operative and post-operative complications, were excluded. The CCT was measured using a Tomey EM-3000, a non-contact specular microscope; axial length and anterior chamber depth were taken from biometry readings by Zeiss IOLMaster®. Phacoemulsification was carried out by two surgeons using the same Alcon Accurus® Phacoemulsifier.

Results: A total of 41 eyes of 33 patients were studied. There was an overall 6.2% decrease in CCT in our study, which showed that despite the endothelial injury expected during phacoemulsification, our study population experienced good healing of their corneas. Corneas of diabetic patients were found to be thicker both before and after surgery likely due to the metabolic changes caused by disease. Anterior chamber depth was found to be a statistically significant predictor of post-operative CCT.

Conclusions: Uncomplicated phacoemulsification surgery has minimal effect in eventual CCT.

Keywords: Cornea, cataract, phacoemulsification, central corneal thickness.

Introduction

The cornea is the most powerful refractive surface of the eye accounting for about three quarters the refractive power of the eye.(1) The average corneal diameter is 11.5mm vertically and 12mm horizontally.(2) Central corneal thickness (CCT) varies with race with Africans found to have thin corneas.(3,4) Nutrition of the cornea is maintained by tears anteriorly and by the aqueous humour posteriorly. The cornea is constantly at about 78% hydration, which is maintained by the innermost layer of the cornea, the endothelial cells, a monolayer of hexagonal cells that

maintain this corneal hydration by constantly pumping out water from the stroma.(2) This function thus maintains corneal thickness and corneal clarity and disruption of these cells may affect these.

Globally, it is estimated that 94 million people are blind or visually impaired with the leading cause being cataracts.(5,6) A systematic review and meta-analysis of population-based eye health surveys between January 1980 and October 2018, found cataracts to be the common cause of blindness in people over 50 years of age, accounting for about 15.2

million cases.(6) Cataract extraction through surgery is the mainstay treatment, with phacoemulsification being the preferred method of surgery due to better outcomes and faster healing time.(7)

Phacoemulsification utilizes ultrasonic energy that causes both mechanical and thermal damage to the endothelial cells.(8) Furthermore, the fluid used intraoperatively and the constricted space that is the anterior chamber in which surgery is performed expose the inner corneal layer of endothelial cells to more loss.(9) The average endothelial cell loss has been found to be between 5-19% and this has a direct relation to CCT post-surgery.(10–12)

Various factors have been found to affect CCT following phacoemulsification such as lens nucleus hardness, phacoemulsification time, corneal endothelial cell count and phacoemulsification energy.(12)

The aim of this study was to establish the changes in the CCT following phacoemulsification that cause loss in endothelial cells and also cause direct thermal and mechanical damage to the cornea. The follow-up period of three months allowed for corneal healing, hence establishing the effects of phacoemulsification relative to the cornea.

Materials and methods

Study design and period

The study was a prospective case series carried out between 1st August 2018 and 30th April 2019.

Study area

The study was carried out at Eagle Eye and Laser Centre (EELC), Lavington, Nairobi. The hospital was chosen because of its diverse catchment population that goes beyond Nairobi residents, to referrals from the rest of the country and the East African region.

Study population

All patients who underwent phacoemulsification surgery between August 2018 to January 2019, and were then followed up for three months post-operatively until April 2019.

Surgical procedures

During the study period, phacoemulsification was carried out by two surgeons using the same Alcon Accurus Phacoemulsifier; CCT was measured using a Tomey EM-3000, a non-contact specular microscope; Zeiss IOLMaster® was used to obtain anterior chamber depth (ACD) and axial length (AL). The CCT and biometry were measured by the same experienced technician, and these machines were well calibrated before the study began. data from the Alcon

Accurus™ captured by one experience theatre nurse.

Inclusion criteria

All eyes undergoing phacoemulsification during the study period were included.

Exclusion criteria:

The exclusion criteria were:

1. Eyes with pre-existing corneal pathology
2. History of ocular infection and/or inflammation
3. Complicated phacoemulsification procedure – intra-operative and post-operative complications.
4. No phacoemulsification power used intra-operatively

Data Collection Methods

The principal investigator led a data collection team consisting of one technician, one scrub nurse and two surgeons. Patients were asked to sign informed consent before being included in the study on manual forms that recorded their names, study number, age, sex, and diabetes status. The CCT readings were the average of two readings to enhance accuracy. The ACD and AL were taken from the biometry readings. The intraoperative phacoemulsification auto-data was obtained by the scrub nurse taking a photo of the Alcon Phacoemulsification machine at the end of each surgery. This intra-operative data was then transferred to the participant forms. The surgeons filled in the forms if there were any intraoperative complications.

Data analysis

The principal investigator uploaded the collected data into Microsoft Excel 2019 sheet. Analysis was done 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%.

Ethical consideration

The tenets of the Helsinki Declaration were adhered to. 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.

Results

A total of 33 patients were studied. This included 18 males and 15 females. Their mean age was 65.5, range was between 26 and 86 years, and a standard deviation 12.3 years. Eight patients had a previous history of diabetes and 11 patients had a history of their eyes having been affected by diabetes.

The total number of operated eyes were 55, and 41 eyes were included in the study (19 right and 22 left eyes). Fourteen eyes were excluded for the following reasons:

- 5 eyes had no phacoemulsification power used intraoperatively
- 5 eyes had intra-operative complications
- 3 eyes had missing post-operative data due to patients' loss to follow-up
- 1 developed post-operative uveitis

Table 1: Pre-operative and post-operative eye measurements

Measurement	Pre-operative value	Post-op Value at 3 months	p-value
Overall mean CCT (mm) (n=41)	505.2 ± 39.5	474.0 ± 41.9	
Mean CCT (mm) Male (n=23)	504 ± 40.6	472.0 ± 39.3	
Mean CCT (mm) Female (n=18)	506.7 ± 39.1	476.6 ± 46.1	
Mean CCT (mm) Right Eyes (n=19)	511.2 ± 48.5	473.7 ± 42.1	
Mean CCT (mm) Left Eyes (n=22)	500.1 ± 30.0	474.3 ± 42.7	
Mean CCT (mm) in Diabetes (n=11)	529 ± 40.1	486.6 ± 39.3	0.05
Mean CCT (mm) in no Diabetes (n=33)	499.3 ± 37.6	471.0 ± 42.5	
Overall Mean ACD(mm) (n=41)	3.7 ± 0.8		
Overall Mean AL (mm) (n=41)	23.8 ± 1.1		
CCT (mm) in AL≤ 25mm(n=35)	501.9	470.6 ± 42.5	0.12
CCT(mm) in AL> 25mm(n=6)	523.1	493.1 ± 35.8	

CCT-Central Corneal Thickness, ACD- anterior chamber depth, AL- axial length

A multivariate analysis (Table 2) of age, diabetic status, axial length and anterior chamber depth has a p value of 0.039.

Table 2: A multivariate analysis of factors affecting change in the central corneal thickness

ANOVA ^a					
Model	Sum of Squares	df	Mean Square	F	Significance
Regression	14872.3	4	3718.1	2.8	0.0 ^b
Residual	47502.1	36	1319.5		
Total	62374.4	40			

a. Dependent variable

b. Predictors (constant), Anterior chamber depth, Diabetes status, axial length

Discussion

The overall mean pre-operative CCT was 505 µm which is typical of African eyes as in keeping with a Congolese study by Kelekele et al.(4), that showed average CCT of 504.2 ± 30.7 µm among healthy Congolese eyes. The mean CCT between male and female patients was similar, which is normal as there are no documented gender differences between the sexes. In our study, diabetics were found to have thicker CCTs, compared to non-diabetics which is in keeping with other studies carried out at different stages of life, as children and adults as shown by Lu et al. and Su et al. respectively in their studies in Singapore.(13,14)

The mean ACD in our study population was found to be higher than that found in studies by Khalid et al. and Hashemi et al. who found a mean of 3.06 ± 0.43mm and 3.09 ± 0.26mm, respectively.(9,15) These studies were however not on African populations so may not represent

participants in our study. The mean AL is in keeping with a study conducted in Nigeria by Oderinlo et al. that showed an average AL 23.21 ± 1.19 mm in their study.(16) Bhardwaj V et al. and Dong et al. describe the normal AL as between 22-25mm.(17,18) In our study, there were no eyes found to have AL of less than 22mm, and 6 eyes were found to have an axial length of >25mm.

The decrease in overall CCT at three months was 6.2% in our study, which suggests that there was no corneal oedema due to loss of endothelial cells after phacoemulsification. This is in contrast to findings by Bamdad et al., who found an increase of 12.9% at three months.(19) The findings in our study may be attributed to minimal loss in endothelial cells and/or strict adherence to a minimum endothelial cell density of ≥2000cells/mm² before phacoemulsification was carried out, hence any loss of endothelial cells was well compensated for.

There was minimal difference between the central corneal thickness of male and female patients.

The corneas of diabetic patients were found to remain thicker than those of patients that were not diabetics, and this was found to be statistically significant. This is in keeping with findings by Chen et al. that found that diabetics had thicker corneas at 1 week, 1 month, 3 months and 6 months postoperatively.(20) These findings were also similar in a metanalysis by Yang et al. that found diabetic patients to have thicker corneas at 3 months post phacoemulsification.(21) In their study, higher random glucose and HbA1C were found to be associate with thicker CCT independent of other confounders.

The ACD was found to be statistically significant in relation in change in CCT in our study ($p=0.040$) This is likely because this is the constricted space within which phacoemulsification takes place hence its depth determines contact between the fluids and ultrasound energy with the cornea, with a negative correlation between depth and resultant postoperative central corneal thickness.

In our study CCT in eyes with long AL greater than 25mm ($n=6$) was found to be higher than those with normal AL ($n=35$). This was in keeping with a study by Muthu et al. evaluating the relationship between AL and CCT found that longer AL was associated with thicker CCT.(22) The percentage change in CCT between the eyes with normal AL vs those with longer AL was found to be comparable at 6.2% and 5.7% respectively. The difference in these changes was not found to be statistically significant ($p=0.12$). A study by Panda et al. did not find any statistically significant correlation between CCT and axial length.(23)

A multivariate analysis of the above factors was also found to be statistically significant ($p=0.039$) meaning that there is a large interplay of these factors in affecting post-operative central corneal thickness.

Conclusions

The findings of this study indicated that phacoemulsification surgery has minimal effect on eventual central cornea thickness three months after the procedure. Patients with diabetes are found to have thicker CCT both preoperatively and postoperatively due to the metabolic changes that are part of the disease process.

Limitations

The factors affecting post-op CCT that were not measured in our study such as cataract lens thickness, intraocular pressure (pre-operative and post-operative) and the type of viscoelastic used intra-operatively.

References

1. Foster JW, Wahlin K, Adams SM, Birk DE, Zack DJ, Chakravarti S. Cornea organoids from human induced pluripotent stem cells. *Sci Rep*. 2017 Jan 27;7:41286.
2. Salmon, J. Kanski's Clinical Ophthalmology, A Systematic Approach. In: 10th ed. Elsevier;
3. Pediatric Eye Disease Investigator Group, Bradfield YS, Melia BM, Repka MX, Kaminski BM, Davitt BV, et al. Central corneal thickness in children. *Arch Ophthalmol Chic Ill 1960*. 2011 Sept;129(9):1132–8.
4. Kelekele JTK, Kayembe DL, Mwanza JC. Profile of central corneal thickness and corneal endothelial cell morpho-density of in healthy Congolese eyes. *BMC Ophthalmol*. 2021 Apr 22;21(1):185.
5. Cicinelli MV, Buchan JC, Nicholson M, Varadaraj V, Khanna RC. Cataracts. *Lancet Lond Engl*. 2023 Feb 4;401(10374):377–89.
6. GBD 2019 Blindness and Vision Impairment Collaborators, Vision Loss Expert Group of the Global Burden of Disease Study. Causes of blindness and vision impairment in 2020 and trends over 30 years, and prevalence of avoidable blindness in relation to VISION 2020: the Right to Sight: an analysis for the Global Burden of Disease Study. *Lancet Glob Health*. 2021 Feb;9(2):e144–60.
7. Li A, He Q, Wei L, Chen Y, He S, Zhang Q, et al. Comparison of visual acuity between phacoemulsification and extracapsular cataract extraction: a systematic review and meta-analysis. *Ann Palliat Med*. 2022 Feb;11(2):551–9.
8. Benítez Martínez M, Baeza Moyano D, González-Lezcano RA. Phacoemulsification: Proposals for Improvement in Its Application. *Healthc Basel Switz*. 2021 Nov 22;9(11):1603.
9. Khalid M, Ameen SS, Ayub N, Mehboob MA. Effects of anterior chamber depth and axial length on corneal endothelial cell density after phacoemulsification. *Pak J Med Sci*. 2019;35(1):200–4.
10. Sahu PK, Das GK, Agrawal S, Kumar S. Comparative Evaluation of Corneal Endothelium in Patients with Diabetes Undergoing Phacoemulsification. *Middle East Afr J Ophthalmol*. 2017;24(2):74–80.
11. Wood K, Pessach Y, Kovalyuk N, Lifshitz M, Winter H, Pikkell J. Corneal endothelial cell loss and intraocular pressure following phacoemulsification using a new viscous-cohesive ophthalmic viscosurgical device. *Int Ophthalmol*. 2024 Feb 6;44(1):10.
12. Hu J, Zhao C, Luo Y, Kong J, Shi W, Wang T. Real-time corneal thickness changes during phacoemulsification cataract surgery. *Graefes Arch Clin Exp Ophthalmol Albrecht Von Graefes Arch Klin Exp Ophthalmol*. 2023 June;261(6):1609–18.

13. Lu HW, Guan YQ, Yuan YZ, Su YD, Zhang SM. Differences in corneal and anterior segment morphology between diabetic vs. healthy children and adolescents: a systematic review and meta-analysis. *Eur Rev Med Pharmacol Sci*. 2022 Mar;26(5):1450–61.
14. Su DHW, Wong TY, Wong WL, Saw SM, Tan DTH, Shen SY, et al. Diabetes, hyperglycemia, and central corneal thickness: the Singapore Malay Eye Study. *Ophthalmology*. 2008 June;115(6):964-968.e1.
15. Hashemi H, Heydarian S, Khabazkhoob M, Emamian MH, Yekta A, Fotouhi A. Anterior chamber depth measurement using Pentacam and Biograph in children. *Clin Exp Optom*. 2022 Aug;105(6):582–6.
16. Oderinlo O, Bogunjoko T, Hassan A, Olowolaiyemo M, Akinye A. Relationship Between Average Keratometric (AK) Readings and Axial Length (AL) Measurements in A Sub-Saharan African Population. *West Afr J Med*. 2024 Oct 30;41(10):1023–7.
17. Bhardwaj V, Rajeshbhai GP. Axial length, anterior chamber depth-a study in different age groups and refractive errors. *J Clin Diagn Res JCDR*. 2013 Oct;7(10):2211–2.
18. Dong J, Zhang Y, Zhang H, Jia Z, Zhang S, Wang X. Comparison of axial length, anterior chamber depth and intraocular lens power between IOLMaster and ultrasound in normal, long and short eyes. *PLoS ONE*. 2018 Mar 15;13(3):e0194273.
19. Bamdad S, Bolkheir A, Sedaghat MR, Motamed M. Changes in corneal thickness and corneal endothelial cell density after phacoemulsification cataract surgery: a double-blind randomized trial. *Electron Physician*. 2018 Apr;10(4):6616–23.
20. Chen Z, Song F, Sun L, Zhao C, Gao N, Liu P, et al. Corneal integrity and thickness of central fovea after phacoemulsification surgery in diabetic and nondiabetic cataract patients. *Arch Med Sci AMS*. 2018 June;14(4):818–25.
21. Yang Y, Chai H, Ding Z, Tang C, Liang Y, Li Y, et al. Meta-analysis of corneal endothelial changes after phacoemulsification in diabetic and non-diabetic patients. *BMC Ophthalmol*. 2023 Apr 24;23(1):174.
22. Muthu Krishnan V, Jayalatha K, Vijayakumar C. Correlation of Central Corneal Thickness and Keratometry with Refraction and Axial Length: A Prospective Analytic Study. *Cureus*. 11(1):e3917.
23. Panda L, Mohapatra S, Khuntia I. A Cross-Sectional Study on Central Corneal Thickness in Relation to Age, Gender, Refractive Errors, And Axial Length Among Patients Visiting Tertiary Care Center in South India. *Eur J Cardiovasc Med*. 2025 Mar 8;15:200–4.

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