ORIGINAL ARTICLE

Retinal Nerve Fiber Layer Thickness Changes after Phacoemulsification with Intraocular Lens Implantation

Arooj Amjad[1], Muhammad Shaheer[1] and Asima Rafique[2]

ABSTRACT

Objective: To determine the changes in the retinal nerve fiber layer as measured on optical coherence tomography (OCT) after phacoemulsification with intraocular lens implantation.

Study Design: Quasi-experimental study.

Place and Duration of Study: Department of Ophthalmology, Lahore General Hospital, Lahore, from March 2017 to April 2018.

Methodology: All patients (n=64) diagnosed with cataract and requiring surgery were included in study. Patients having any coexisting ocular pathology hindering the OCT measurement, i.e. corneal opacity, vitreous hemorrhage, retinal detachment etc. were excluded from study. Retinal nerve fiber layer thickness was measured in four quadrants. Signal strength on OCT was also documented. Preoperatively, visual acuity was measured, OCT performed, and the findings were recorded on a designed proforma. Postoperatively, the patients followed up after one month for visual acuity and OCT measurement.

Results: Retinal nerve fiber layer thickness was increased postoperatively as measured on OCT as did the signal strength. The increase was statistically significant ($p < 0.001$).

Conclusion: Removal of cataract by surgery enhances the OCT measurement of retinal nerve fiber layer, resulting in increased thickness.

Key Words: *Phacoemulsification, Retinal nerve fiber layer, Optical coherence tomography.*

INTRODUCTION

Cataract surgery is one of the most consistently performed surgeries around the world. During cataract surgery, the opaque cataractous lens is replaced by an artificial, transparent intraocular lens.[1] Since its start two centuries back, the cataract surgery has gone through various stages of refinement. Intracapsular cataract extraction[2] was refined to extracapsular cataract extraction,[3] in which the lens capsule was preserved for the implantation of artificial intraocular lens. Currently, phacoemulsification is the surgery of choice for cataract due to its minimal per- and postoperative complications and an early visual recovery with better patient comfort.[4-6]

Retinal nerve fiber layer is one of the vital layers of the retina with regard to the incidence and subsequent treatment of glaucoma. The damage done by glaucoma specifically involves this layer.[7,8] OCT is a non-invasive medical diagnostic imaging technology that captures three dimensional micro-resolution images of retina. It is based on the principle of optical reflectometry which involves the measurement of light back scattering through transparent or semi-transparent media such as biological tissues.[9] Various models of OCT are available, which measure the retinal nerve fiber layer thickness and there is agreement between them regarding measurement of retinal nerve fiber layer thickness.[10]

Measurement of retinal nerve fiber layer thickness by OCT is affected by various factors such as age, gender, axial length, race and optic nerve head parameters, so these must be kept into account while making any decision regarding any treatment.[11,12] Literature suggests that ocular surgery, whether that of the anterior segment or of the posterior segment, does affect the retinal nerve fiber layer thickness.

The objective of this study was to determine the changes in the retinal nerve fiber layer as measured on OCT after phacoemulsification with intraocular lens implantation.

METHODOLOGY

Ethical approval of this study was obtained from the Hospital Ethical Review Committee. Patients presenting to the eye outpatient department were assessed for inclusion and exclusion criteria. All patients (n=64) diagnosed with cataract requiring surgery were included in study. Patients having any coexisting ocular pathology hindering the OCT measurement, *i.e.* corneal opacity, vitreous hemorrhage, retinal detachment were excluded from study. Retinal nerve fiber layer thickness was measured in four quadrants, i.e. superior, inferior, nasal,

[1] *Department of Ophthalmology, Lahore General Hospital, Lahore, Pakistan*

[2] *Department of Ophthalmology, Mayo Hospital, Lahore, Pakistan*

Correspondence: Dr. Muhammad Shaheer, Department of Ophthalmology, Lahore General Hospital, Lahore, Pakistan
E-mail: mshaheer212@gmail.com

Received: July 12, 2018; Accepted: September 25, 2018

and temporal. Besides, signal strength on OCT was also documented. Preoperatively, visual acuity was measured and OCT performed and the findings were recorded on a designed proforma.

After aseptic measures, opsite was applied on the eye to be operated and stab incision was made at the limbus. Viscoelastic was injected into the anterior chamber and continuous curvilinear capsulorhexis was performed. The lens nucleus was separated from lens cortex and lens cortex was separated from lens capsule by hydro-dissection and hydrodilineation. The lens was emulsified by phacoemulsification and an intraocular lens was implanted. Postoperative steroid and antibiotic drops were given every four hours for two weeks and four times daily for the next two weeks. The patients were called for follow-up after one month; at which time, visual acuity was again measured and OCT performed and findings recorded in the proforma. All the surgeries were performed by single surgeon.

All data analyses were carried out on SPSSP version 22 for Windows. Quantative variables were presented by their mean and standard deviation values; however, the qualitative variables were presented as frequencies and percentages. Paired samples t-test was applied to determine the difference between retinal nerve fiber layer thickness preoperatively and one month post-operatively. The p-value $\leq$0.05 was considered as statistically significant.

RESULTS

The mean age of patients was 60.20 ±5.25 years. Out of 64 patients, 36 (56.3%) were males and 28 (43.8%) were females. Phacoemulsification was done in left eye of 29 (45.3%) patients and in right eye of 35 (54.7%) patients. Presurgery visual acuity was 6/36 in 20 (31.3%) patients, while it was 6/60 in 44 (68.8%) patients. Postsurgery visual acuity was 6/6 in 38 (59.4%) patients, 6/9 in 12 (18.8%) patients, 6/12 in 8 (12.5%) patients, and 6/18 in 6 (9.4%) patients (Table I).

Preoperatively, the geographic retinal nerve fiber layer thickness was 84.53 ±4.08 microns, which increased to 88.02 ±3.63 microns one month after surgery. The superior retinal nerve fiber layer thickness before surgery was 86.70 ±4.10 microns, which increased to 92.42 ±4.32 microns after one month of surgery. Inferior retinal nerve fiber layer thickness preoperatively was 88.27 ±4.55 microns, which later on increased to 94.05 ±5.20 microns postoperatively. The temporal retinal nerve fiber layer thickness before surgery was 86.16 ± 4.68 microns, which increased to 91.56 ±4.72 microns after one month of surgery. Nasal retinal nerve fiber layer thickness was 85.25 ±4.04 before surgery, and it was 91.08 ±4.84 microns after surgery. The signal strength on OCT before surgery was 5.41 ±0.50 microns and it was 8.53 ±0.50 microns postsurgery. The increase in thickness of retinal nerve fiber layer and signal strength on OCT was statistically significant (p <0.001, Table II).

Table I: Age, gender, laterality and visual acuity characterictics.

Parameter	n
Age in years*	60.20 ±5.25
Gender	
Male	36 (56.3%)
Female	28 (43.8%)
Eye (laterality)	
Left	29 (45.3%)
Right	35 (54.7%)
Pre-phacoemulsification visual acuity	
6/36	20 (31.3%)
6/60	44 (68.8%)
Post-phacoemulsification visual acuity	
6/6	38 (59.4%)
6/9	12 (18.8%)
6/12	8 (12.5%)
6/18	6 (9.4%)

**Continuous variable was presented as Mean±Standard deviation*
Categorical variables were presented as frequencies and percentages.

Table II: Change in retinal nerve fiber layer thickness.

Parameter	Pre-surgery	One month post-surgery	p-value
Total	84.53 ±4.08	88.02 ±3.63	<0.001
Superior	86.70 ±4.10	92.42 ±4.32	<0.001
Inferior	88.27 ±4.55	94.05 ±5.20	<0.001
Temporal	86.16 ±4.68	91.56 ±4.72	<0.001
Nasal	85.25 ±4.04	91.08 ±4.84	<0.001
Signal strength	5.41 ±0.50	8.53 ±0.50	<0.001

Retinal nerve fiber layer thickness was measured in microns.

Continuous variables were expressed as mean ±standard deviation and paired sample t-test was applied. The p-value <0.05 was considered as statistically significant.

DISCUSSION

This study showed that the thickness of retinal nerve fiber layer is increased on OCT after cataract is removed by surgery. This change in morphology of retinal nerve fiber layer was statistically significant.

El-Ashry *et al*. evaluated the changes in retinal nerve fiber layer measurement on OCT after phacoemulsification cataract surgery.[13] In their study, the mean retinal nerve fiber layer thickness measured 84.9 ±16.5 microns, which increased to 93.0 ±17.6 microns postoperatively. This was statistically a significant increase.

Mwanza *et al*. studied the effect of cataract removal by surgery, on the retinal nerve fiber layer and signal strength measurement on OCT.[14] They documented an increase of 9.3% in retinal nerve fiber layer thickness and 24.1% increase in signal strength on OCT after cataract surgery. This increase in signal strength and

retinal nerve fiber layer thickness was statistically significant. They also noted that the increase in thickness was more in patients who had preoperative signal strength of less than 6 as compared to those having signal strength greater than 6.

Dada and associates studied the effect of cataract surgery on retinal nerve fiber layer parameters as measured on scanning laser polarimetry.[15] This study showed an increase in retinal nerve fiber layer thickness from 49.2 ±14.1 microns to 56.5 ±7.6 microns after four weeks of cataract surgery, which was statistically significant.

Pauline and colleagues studied the changes in retinal nerve fiber layer thickness after cataract removal surgery and measured them by two models of spectral domain OCT (Cirrus HD OCT, Zeiss and 1000Mark II, Topcon).[16] The Cirrus HD OCT measured an increase in the thickness of retinal nerve fiber layer from 85.94 ±10.7 to 90.56 ±9.9 microns after cataract surgery, while the 1000 Mark II measured an increase in the thickness of retinal nerve fiber layer from 91.27 ±8.1 to 103.14 ±9.7 microns after cataract surgery.

Pareja-Esteban *et al*. have analysed parapapillary retinal nerve fiber layer behavior after cataract surgery.[17] However, in their study, the preoperative thickness of retinal nerve fiber layer was 90.71 ±19.93, which increased to 97.45 ±14.30 microns after one month of cataract surgery. This increase in the thickness was statistically significant.

Aydin and associates studied the changes in thickness of the retinal nerve fiber layer after filteration surgery.[18] An increase of 0.5 μm in thickness of retinal nerve fiber layer for every 1 mm of Hg reduction in the intraocular pressure was observed. Hence, it was inferred that 30% reduction in the intraocular pressure, as a result of trabeculectomy, leads to increased thickness of the retinal nerve fiber layer.

Young-Joon and colleagues studied the changes in thickness of retinal nerve fiber layer in 20 patients after giving them anti-VEGF therapy *via* intravitreal injections.[19]

It was found that the total thickness decreased on average from 98±6.8 to 96.3±4.2 microns after six months long therapy of intravitreal anti-VEGF injections. The inferior zone thickness reduced from 120.9 ±10.1 to 120.7 ±9.3 microns and that of the superior zone reduced from 122.8 ±10.2 to 121.8 ±6.5 microns. However, this change in thickness was not statistically significant.

Hatata *et al*. studied changes in the thickness of retinal nerve fiber layer (RNFL) after intravitreal injection of triamcinolone acetonide in patients with macular edema.[20] In this study, the mean average retinal nerve fiber layer thickness is decreased from 91.63 ±10.5 to 90.83 ±10.11 microns. The mean superior RNFL thickness decreased from 104.57 ±15.3 to 103.08±15.3 microns. The mean inferior RNFL thickness changed from 118.9 ±19.95 to 111.8 ±19.95 microns. The decrease in RNFL thickness was, however, clinically and statistically insignificant.

Lee and associates studied RNFL changes after pars plana vitrectomy done for epiretinal membrane peel.[21] The comparison between the involved and un-involved eye showed that the mean thickness of RNFL was increased at baseline (112.88 ±12.66 and 102.94 ±11.58 microns) and at one month postoperatively (112.63 ±15.43 and 102.95 ±11.49 microns) but it was decreased at 12 months postoperatively (94.47 ±13.53 and 103.57 ±9.0 microns).

Entazari *et al*. studied changes in the thickness of RNFL thickness after two consecutive intravitreal injections of bevacizumab for neovascular age-related macular degeneration.[22] Changes in the thickness of RNFL in all four quadrants were studied at week 12 and week 24 post-intravitreal bevacizumab injections. In this study the thickness of RNFL was decreased from baseline at week 24 in superior, temporal and nasal quadrants, but it was increased in the inferior quadrant.

CONCLUSION

Cataract affects the measurement of retinal nerve fiber layer thickness as measured on OCT; and cataract surgery enhances the ability of OCT to measure the changes in retinal layers.

REFERENCES

1. Lundstrom M, Goh PP, Henry Y, Salowi MA, Barry P, Manning S, *et al*. The changing pattern of cataract surgery indications. *Ophthalmology* 2015; **122**:31-8.
2. Thompson J, Lakhani N. Cataracts. *Primary Care: Clinics in Office Practice* 2015; **42**:409-23.
3. Mahmud I, Kelley T, Stowell C. A proposed minimum standard set of outcome measures for cataract surgery. *JAMA Ophthalmol* 2015; **133**:1247-52.
4. Gogate P, Jaggernath JB, Deshpande S, Naidoo K. Meta-analysis to compare the safety and efficacy of manual small incision cataract surgery and phacoemulsification. *Middle East Afr J Ophthalmmol* 2015; **22**:362-9.
5. El-Sayed SH, El-Sobky HM, Bdaway NM, El-Shafy EAA. Phacoemulsification versus manual small incision cataract surgery for the treatment of cataract. *Menoufia Med J* / 2015; **28**:191-6.
6. Agarwal A, Jacob S. Current and effective advantages of femto phacoemulsification. *Cur Opin Ophthalmol* 2017; **28**:49-57.
7. Kim YW, Lee EJ, Kim TW, Kim M, Kim H. Microstructure of b-zone parapapillary atrophy and rate of retinal nerve fiber layer thinning in primary open-angle glaucoma. *Ophthalmology* 2014; **121**:1341-9.
8. Mikki A, Medeiros FA, Weinreb RN, Jain S, He F. Rates of retinal nerve fiber layer thinning in glaucoma suspect eyes. *Ophthalmology* 2014; **121**:1350-8.

9. Talisa EDC, Andre R, Nadia KW, Jay SD. A review of optical coherence tomography angiography (OCTA). *Int J Retina Vitreous* 2015; **1**:1-15.

10. Tan B, Natividad M, Chua KC, Yio L. Comparison of retinal nerve fiber layer measurement between two spectral domain OCT instruments. *J Glaucoma* 2012; **21**:266-73.

11. Jung KI, Jung Y, Park KT, Park CK. Factors affecting plastic lamina cribrosa displacement in glaucoma patients. *Investig Ophthalmol Vis Sci* 2014; **55**:7709-15.

12. Hae-Young LP, Chan KP. Diagnostic capability of lamina cribrosa thickness by enhanced depth imaging and factors affecting thickness in patients with glaucoma. *Ophthalmology* 2013; **120**:745-52.

13. El-Ashry M, Appaswamy S, Deokule S, Pagliarini S. The effect of phacoemulsification cataract surgery on the measurement of retinal nerve fiber layer thickness using optical coherence tomography. *Cur Eye Res* 2006; **31**:409-13.

14. Mwanza JC, Bhorade AM, Sekhon N, McSoley JJ, Yoo S. Effect of cataract and its removal on signal strength and peripapillary retinal nerve fiber layer optical coherence tomography measurements. *J Glaucoma* 2011; **20**:37-43.

15. Dada T, Behera G, Agarwal A, Kumar S, Sihota R, Panda A. Effect of cataract surgery on retinal nerve fiber layer thickness parameters using scanning laser polarimetry (GDxVCC). *Indian J Ophthalmol* 2010; **58**:389-93.

16. Pauline HHK, Thomas JTPV, Hille WD, Marilette S, Ivanka JEV. The relationship between optical density of cataract and its influence on retinal nerve fiber layer thickness measured with spectral domain optical coherence tomography. *Acta Ophthalmologica* 2013; **91**:418-24.

17. Pareja-Estaban J, Teus-Guezala MA, Drake-Casanova P, Dapena-Sevilla I. Retinal nerve fiber layer changes after cataract surgery: A pilot study. *Arch Soch Esp Oftalmol* 2009; **84**:305-10.

18. Aydin A, Wollstein G, Price LL, Fujimoto JG, Schuman JS. Optical coherence tomography of retinal nerve fiber layer thickness changes after glaucoma surgery. *Ophthalmology* 2003; **110**:1506-11.

19. Young-Joon J, Woo-Jin K, Il-Hwan S. Longitudinal changes in retinal nerve fiber layer thickness after intra vitreal anti vascular endothelial growth factor therapy. *Korean J Ophthalmol* 2016; **30**:114-20.

20. Hatata RM, Aly NH, Hassib HM. Comparative study between pre- and post-intravitreal injection of triamcinolone acetonide regarding RNFL thickness in macular edema by OCT. *EC Ophthalmology* 2017; **5**:150-5.

21. Lee SB, Shin YI, Jo YJ, Kim JY. Longitudinal changes in retinal nerve fiber layer thickness after vitrectomy for epiretinal membrane. *Investig Ophthalmol Vis Sci* 2014; **55**:6607-11.

22. Entazari M, Ramenzeni A, Yaseri M. Changes in retinal nerve fiber layer thickness after two intravitreal bevacizumab injections for wet type age related macular degeneration. *J Ophthalmic Vis Res* 2014; **9**:449-52.