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To Assess the Retinal Nerve Fibre Layer (RNFL) Thickness and Signal Strength before and after Phacoemulsification Cataract Surgery

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Abstract
The lens is a transparent biconvex structure in the eye that helps to refract light to focus on the retina. Cataract is opacity of lens or capsule which is either developmental or acquired. To assess the retinal nerve fibre layer (RNFL) thickness, signal strength before and after phacoemulsification cataract surgery. To assess the effect of media opacity like cataract on OCT measurements. Methods: A hospital based Prospective, Single Centre study was carried out Patients attending the Ophthalmology OPD who gave a written informed consent to be a part of this study at tertiary care Centre. The study was conducted from August 2022 to August 2023. The mean age at presentation was 59.50 ±7.81 years. 89 (44.5%) are females and 111(55.5%) are male. 14 (7%) were having cortical cataract, 47 (23.5%) nuclear cataract only, 23 (11.5%) had posterior sub capsular cataract only and 116 (58%) of the eyes had both nuclear and posterior sub capsular cataract together. Mean Signal strength pre and post-surgery is 4.8±1.24 and 7.8 ±0.79 respectively. Mean RNFL thickness increased from 75.62±13.8µm to 92.01±12.94µm post operatively. There is statistically significant increase in RNFL thickness and signal strength in both glaucoma and non-glaucoma patient's. In conclusion, our data suggest that the presence of lenticular opacity significantly affects RNFL thickness measurements, signal strength using Cirrus OCT. In clinical practice, an increase in RNFL thickness, signal strength can be expected after cataract surgery and we recommend obtaining fresh OCT images after cataract surgery to define a new baseline for patients who need glaucoma follow-up.

INTRODUCTION

Cataract is one of the leading causes of blindness especially in the developing world and is reported to be responsible for 50-80% of bilateral blindness in India[1]. Cataract, being the major cause of ocular morbidity, is the most common treatable blindness in the world. At the same time surgery for cataract is the most rewarding and commonest of all surgeries in ophthalmology. Nuclear cataract is the most common form of age related cataract in India and worldwide[2]. Phacoemulsification is a modern cataract surgery and it continues to be one of the most popular surgical procedures for cataract extraction in the ophthalmologic practice. It is a surgical intervention which uses an ultrasonic device to emulsify the cataractous lens and aspirated from the eye.

Cataracts are classified as nuclear, cortical, or posterior sub capsular, based on the highest score using the Lens Opacities Classification System III (LOCS III) scoring system. LOCS III was introduced in 1993 as a subjective grading system for cataract using slit lamp, with accuracy comparable to objective methods[3]. It is a standardized photographic comparison of standard images of 8.5-inch x 11-inch used in the office at the slit-lamp microscopy for grading the features of cataract. It's been used to grade the type and severity of cataract. The brightness of scatter from the nuclear region has been designated nuclear opalescence (NO) and the intensity of brunescence, nuclear color (NC). The amount of cortical cataract and the estimated amount of posterior subcapsular cataract is determined by comparing with standard images[4]. Optical coherence tomography (OCT) is a user-friendly, non-contact, high resolution, cross sectional imaging technique which allows in-vivo measurement of the retinal nerve fibre layer (RNFL). OCT images are representations of the tissue structure based on the intensity of light back scattering, which is highly dependent on the optical properties of the structure. Altered ocular media transparency leads to reduction of the signals reflected from the retina and might therefore affect the image quality. Few studies used OCT to assess the influence of media opacities like cataract on OCT image quality and found to have RNFL thickness measurements affected by the cataract.

Based on the amount of light reflected between the outer edge of the RNFL and the internal limiting membrane (ILM), the thickness of the RNFL is captured on OCT[5]. RNFL Circular scans are centered around the ONH in order to capture RNFL and ONH measurements

MATERIALS AND METHODS

A hospital based Prospective, Single Centre study was carried out Patients attending the Ophthalmology OPD who gave a written informed consent to be a part of this study at tertiary care Centre. The study was conducted from August 2022-August 2023

Sample Size: 200 eyes.

Inclusion Criteria:

- Suitable lens opacities (cataract) not interfering with OCT examination.
- Patients giving consent for the study.

Exclusion Criteria:

- Patients with retinal diseases like macular degeneration, macular hole, vascular diseases, epiretinal membranes.
- Ocular diseases like uveitis, previous history of intraocular surgery and laser treatment.
- Patients who had systemic diseases like diabetes that could affect the eye.
- History of ocular injury / blunt trauma
- Corneal pathologies like dystrophies, degeneration, ectasia (irregular surface)
- Patients who were on topical or systemic steroid or diuretics that may affect retinal thickness
- Patients with dense cataract interfering with OCT analysis
- Those who do not sign the consent
- Non cooperative patient

Materials/ Tools:

- **Cataract Grading:** LOCS III standard images in a 8.5-inch x 11- inch color transparency. Slit lamp image of every eye is compared with 6 standard color photographic transparencies on a scale of 0-6 of LOCS III which is in the top most row of colour transparency.
- **SD-OCT:** CIRRUS HD-OCT machine (fig 24) was used for measurements. These recordings were taken by an experienced examiner. RNFL thickness measurements were obtained by OCT machine using the Optic Disc 200x200 protocol. The RNFL thickness was compared with the age and sex matched normative database. Of the obtained RNFL parameters the Average RNFL Thickness was noted before and after phacoemulsification procedure.
- **Phacoemulsification Machine:** ALCON CONSTELLATION phacoemulsification machine was used for cataract surgery of all patients included in the study.

Methodology: After obtaining their informed written consent, detailed history and examination (general, local) will be done by the investigator herself.

A complete ophthalmologic examination included best-corrected visual acuity by Snellen's visual acuity chart. The anterior segment of each eye examined by slit-lamp for corneal opacities or abnormalities, depth of anterior chamber, uveitis, and lens position. Cataract grading done using LOCS III system. The Fundus examination was done by indirect ophthalmoscope and 90D lens for examination of the macula, optic disc, retinal vessels, retinal background, and retinal nerve fiber.

After assessing patients for inclusion and exclusion criteria, they are posted for phacoemulsification cataract surgery. Signal strength of all scans noted on all visits.

Peripapillary RNFL thickness and macular thickness measured using optical coherence tomography (OCT) 1 day before and 1 week after surgery. The average of these scans was used for the analysis.

Statistical Analysis: The clinical data collected was entered in MS Office Excel and analysed using Statistical package software [SPSS 20.0].Data is presented in the form of tables, figures, graphs, wherever necessary. Descriptive statistics were calculated in the form of: Mean and Standard deviation (±SD), Median and Inter-Quartile Range (IQR) for quantitative data. Frequency and Distribution for qualitative data, wherever necessary.

For the statistical comparison between the Pre-operative and Post-operative groups, the significance of difference was tested using: Paired t-test for normally distributed data. Pearson Chi-square test of significance was used to find the association between the categorical variables where-ever applicable. P-value <0.05 is considered as statistically significant.

RESULTS AND DISCUSSION

15.5% were between age group of 45-50, 20.0% were between the age group of 51-55. The mean age at presentation was 59.50±7.81 years. 89 (44.5%) are females and 111(55.5%) are male.

(Table 3) shows, among 89 females maximum distribution was in 51-55 age groups and among 111 males it was found in 61-65 years of age.

14 (7%) were having cortical cataract, 47 (23.5%) had nuclear cataract only, 23 (11.5%) had posterior sub capsular cataract only and 116 (58%) of the eyes had both nuclear and posterior sub capsular cataract together. Majority of the patients had nuclear with capsular cataract during presentation.

This table shows the analysis of 200 eyes for signal strength, RNFL thickness. Mean Signal strength is 4.8 ±1.24 with maximum and minimum score being 2 and 8 respectively. Mean RNFL thickness is 75.62 ± 13.8µm with maximum and minimum thickness being 38µm and 99µm respectively.

Impression: This (table 4) shows the analysis of 200 eyes for signal strength, RNFL thickness. Mean Signal strength is 7.8±0.79 with maximum and minimum score being 6 and 9 respectively. Mean RNFL thickness is 92.01±12.94µm with maximum and minimum thickness being 53µm and 112µm respectively.

(Table 5) shows the statistical analysis of signal strength pre and post operatively. In this study P-value is <0.05, hence this proves that there is a statistically significant association between Pre and Post-op signal strength. Therefore the increase in signal strength post operatively is statistically significant

(Table 6) shows the statistical analysis of RNFL thickness pre and post operatively. In this study P-value is <0.05, hence this proves that there is a statistically significant association between Pre and Post-op RNFL thickness. Therefore the increase in RNFL thickness post operatively is statistically significant.

The statistical analysis of RNFL thickness and signal strength pre and post operatively. In this study P-value is <0.05, hence this proves that there is a statistically significant association between Pre and Post-op RNFL thickness and signal strength. Therefore the increase in RNFL thickness and signal strength post operatively is statistically significant

In recent times, OCT has become an indispensable technique for the high resolution cross sectional imaging of retina. RNFL thickness measurement using OCT has relevance clinically in the prognosis of disease and planning of treatment plan. Cataract and glaucoma are often seen to co-exist in the elderly. Media opacities like cataract interfere with the analysis of the OCT. With this background the results of the study were analyzed and discussed.

A total of 200 eyes with cataract were recruited. All the patients were subjected to RNFL analysis pre operatively and after undergoing phacoemulsification. The pre-operative and post-operative readings were compared and analyzed statistically.

In the present study mean age was 59.50±7.81 years and the range was 45-77 years which is similar to following studies. Jha[6] who reported a mean age of 56.6±12.3 years in their study.

Of the 200 eyes included in the present study 14 (7%) were having cortical cataract only, 47 (23.5%) had nuclear cataract only, 23 (11.5%) had posterior sub capsular cataract only and 116 (58%) of the eyes had

Table 1: Age Distribution

Age Category	Frequency	Percent
45-50	31	15.5
51-55	40	20.0
55-60	39	19.5
61-65	39	19.5
66-70	34	17.0
71-75	15	7.5
>75	2	1.0
Total	200	100.0
		AGE
Mean		59.49
Std. Deviation		7.818
Minimum		46
Maximum		77

Table 2: Age Category * Sex Cross Tabulation

	Sex			Total
		Female	Male	
Age Category	>75	0	2	2
	45-50	14	17	31
	51-55	23	17	40
	55-60	17	22	39
	61-65	14	25	39
	66-70	17	17	34
	71-75	4	11	15
Total		89	111	200

Table 3: Pre Operative Parameters Analysis

	Age	PRE-OP Signal Strength	PRE-OP RNFL Thicken
S (µm)			
Mean	59.49	4.8	75.62
Std. Deviation	7.818	1.24	13.843
Minimum	46	2	38
Maximum	77	8	99

Table 4: Post Operative Parameters Analysis

	Signal Strength	POST-OP RNFL Thickness(µm)
Mean	7.87	92.01
Std. Deviation	0.791	12.945
Minimum	6	53
Maximum	9	112

Table 5: Pre and Post-OP Signal Strength Analysis

Paired Samples Statistics	Mean	N	Std. Deviation	Std. Error Mean
Pre-OP Signal Strength	4.8	200	1.24	0.088
Signal Strength	7.87	200	0.791	0.056

Paired Samples Test	Paired Differences					t	df	Sig. (2- tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	upper			
Pre-op signal strength -signal strength	-3.070	1.246	.088	-3.244	-2.896	-34.841	199	.000

Table 6: Pre and Post-OP RNFL Thickness

Paired Samples Statistics(Paired t- test)	Mean	N	Std. Deviation	Std. Error Mean
Pre-Op RNFL Thickness (µm)	75.62	200	13.843	0.979
Post-OP RNFL Thickness(µm)	92.01	200	12.945	0.915

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pre-OP RNFL Thickness (µm)-Post-OP RNFL Thickness (µm)	- 16.395	7.142	.505	-17.391	-15.399	- 32.462	199	.000

both nuclear and posterior sub capsular cataract together. Majority of the patients had nuclear with capsular cataract during presentation. But Kok[7] study had nuclear: cortical: posterior 9:17:2 with cortical cataract being maximum.

Of 200 eyes analysed in present study Mean RNFL thickness pre operatively is 75.62±13.8µm with maximum and minimum thickness being 38µm and 99µm respectively. The RNFL thickness increased post-surgery with Mean RNFL thickness 92.01±12.94µm with maximum and minimum thickness being 53µm and 112µm respectively which was proven to be statistically significant. our study results corroborated with several other studies as follows:

Jha[6] study showed the average RNFL increased from 92.6 ± 5.4µm to 101.3 ± 5.6µm after phacoemulsification.

El-Ashry[8] reported that OCT after phacoemulsification surgery the mean RNFL thickness measured 84.9 ±16.5 microns, which increased to 93.0 ±17.6 microns postoperatively.

Dhaka[9] study results showed RNFL thickness measurements increased from 85.42±10.15µm to 91.08±10.77µm post cataract surgery.

Nasar[10] showed an average retinal nerve fiber thickness of 96.52±12.00µm pre operatively increased to 111.96±11.43µm post operatively.

Lee[11] documented preoperatively, average RNFL thickness was 93.1±16.6 µm which increased to 97.9±17.9 µm postoperatively (P<0.001). RNFL thickness increased significantly in all four quadrants after cataract surgery.

Darma[12] reported a pre operative RNFL thickness of 96.0±5.9µm which increased to 98.5± 7.0µm post cataract surgery

Abdo[13] showed in their study that the Pre-operative Retinal Nerve Fiber layer thickness 83.1±12.36 µm increased to 107.8±21.56 µm post 1month of cataract surgery.

Mwanza[14] documented an increase of 9.3% in retinal nerve fiber layer thickness on OCT after cataract surgery.

Amjad[15] reported statistically significant retinal nerve fiber layer thickness increase on optical coherence tomography (OCT) after phacoemulsification with intraocular lens implantation. Of 200 eyes analysed in present study Mean Signal strength is 4.8±1.24 pre operatively increasing to Mean Signal strength of 7.8±0.79 post operatively due to removal of media opacity after cataract removal. Our results corroborated with results of following studies: Mwanza[14] reported that the postoperative Signal Strength was 24.1% (P<0.001) higher than before surgery.

Jha[6] study showed the signal strength increased from 5.6±0.5 to 7.6±0.7 post phacoemulsification cataract surgery

Lee[11] documented Mean preoperative Signal strength was 6.0±1.3 which improved to 6.8±1.5 postoperatively (P<0.001).

Van Velthoven[16] showed that signal strength increased significantly postoperatively from 5.87± 1.86 to 7.94 ±1.36.

Kwak[17] the signal strength of OCT was significantly increased from 28.79 dB-31.67dB.

Amjad[15] reported statistically significant signal strength increase on optical coherence tomography (OCT) after phacoemulsification with intraocular lens implantation.

In the present study out of 200 eyes considered 23 eyes were diagnosed with glaucoma pre operatively and underwent standard methodology as rest of the patients. These eyes showed a statistically significant increase in both RNFL thickness and signal strength post cataract surgery. Similar results were seen in study by:

Perdana[18] were average RNFL thickness in glaucoma group before and after phacoemulsification were 94.9±20.0µm and 99.1±21.3µm.

Shahid[19] compared the changes in Retinal Nerve Fiber Layer (RNFL) thickness after phacoemulsification in patients with glaucoma and reported an increase from 74.57±7.99µm to 85.90±5.44µm.

Kim[20] found that the pre-operative RNFL thickness of 73.56±16.14µm increased post cataract surgery to 80.75±16.09µm in glaucoma patients.

CONCLUSION

A Prospective, Single Centre study was done to study the effect of media opacity like cataract on the OCT parameters i.e. signal strength, RNFL thickness in glaucoma and non-glaucoma patients. Patients were examined and underwent phacoemulsification cataract surgery.

From the OCT reports noted and compared before and after cataract surgery in our study we can conclude that the media opacity like cataract impedes signal transmission to and reflection from the retina. The change in RNFL and signal strength post-surgery can be explained by the fact that cataract delays time-of-flight information, in turn, affects the spatial delineation of RNFL layer leading to a falsely low measurement on OCT imaging.

We found all the subtypes of cataract (cortical, nuclear, posterior sub capsular and mixed type) to

significantly affect RNFL measurement, signal strength and macular thickness in both non glaucoma patients and glaucoma patients.

In conclusion, our data suggest that the presence of lenticular opacity significantly affects RNFL thickness measurements, signal strength using Cirrus OCT
In clinical practice, an increase in RNFL thickness, signal strength can be expected after cataract surgery and we recommend obtaining fresh OCT images after cataract surgery to define a new baseline for patients who need glaucoma follow-up

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