Original Article

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Optical Coherence Tomographic Assessment of Macula following Uncomplicated Cases of Cataract Surgery

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ABSTRACT

Introduction: Optical coherence tomography (OCT) is a non-invasive tool in detecting and quantifying the macular thickness associated with cystoid macular oedema (CME). Very few studies have assessed the behaviour of the macular thickness with Spectral Domain/ Stratus OCT in Indian population. The objective of the present study was to evaluate the behaviour of central macular thickness (CMT) in patients who underwent uncomplicated cataract surgery utilizing Spectral Domain OCT.

Methodology: The present study comprised of 50 patients (50 eyes) who had undergone uncomplicated cataract surgery by phacoemulsification method. All patients included in the study underwent OCT and CMT for each eye and were followed at four, eight, and twelve weeks after uncomplicated cataract surgery.

Results: A statistically significant difference was observed between best corrected visual acuity (BCVA) at days 28 v/s 56; and days 28 v/s 84 respectively but no significant difference was observed at day 56 v/s day 84. No significant difference was observed when mean CMT was compared at days 28 v/s 56, 56 v/s 84, and 28 v/s 84, respectively. A statistically significant effect of BCVA was observed on CMT at post-operative days 28 and 56 ,respectively but no significant effect was observed at post-operative day 84. A significant difference was observed between mean CMT less than 270 microns and more than 270 microns at day 28. The effect of age on CMT at post-operative days 28, 56, and 84 was not significant.

Conclusion: Spectral Domain/Stratus OCT is a useful and non-invasive diagnostic tool in assessing the macular changes in uncomplicated cataract surgery.

INTRODUCTION

It is well established fact that uncomplicated cataract surgery with phacoemulsification results in many morphological changes in macula.[1-5] One of the most important factors responsible for poor visual recovery after an uncomplicated cataract surgery is development of cystoid macular edema (CME). Breakdown of blood retinal barrier results in a development of pathological state called as CME, by cystic accumulation of fluid in the inner nuclear and outer plexiform layers of retina.[6] Early detection of CME is significant as it helps in determining the duration of treatment and may affect the patient's final visual outcome. Fluorescein angiography (FA) is considered as a traditional tool for diagnosing CME but it is an invasive contrast assisted modality. CME is acknowledged as "classic flower petal leakage pattern" in fundus FA. However, presence of retinal hemorrhages and exudates possess a difficulty in the interpretation of findings of FA.[7] Therefore, studies have been conducted to find out other techniques to detect and confirm clinical macular edema after cataract surgery.

Optical Coherence Tomography (OCT) technology is used as a diagnostic aid which performs micro resolution tomographic or cross-sectional imaging of biologic tissues.[8] It can be used in detecting and quantifying the macular oedema, its proximity to fovea, and response to therapy.[9] This technique has been used for quantitative analysis of macular thickness in various studies and the results were found reproducible with minimal intra or

inter observer variation. Data is now also available for macular thickness in various physiological states like gender, race, as well as pathological conditions like diabetes mellitus and age-related macular degeneration.[10-11] Determination of normative values for macular thickness and volume by OCT in healthy Indian subjects has been conducted.[12]

For clinical screening of macular oedema, OCT seems to be more suitable than other measurement techniques like retinal thickness analyser (RTA) due to its high sensitivity (>90%) with appropriate analysis parameters.[13] Spectral domain OCT (SD-OCT) has shown greater ability in assessing qualitative features suggesting disease activity and fewer errors in automated segmentation when compared to time domain OCT (TD-OCT).[14] Therefore, Zeiss Cirrus SD HD-OCT was chosen as the macular thickness measurement instrument for this study.

Apart from CME, there are many macular disorders responsible for poor visual recovery after cataract surgery like AMD and epiretinal fibrosis. Even for diagnosing these conditions, OCT is useful and above all non-invasive.[15-16] However, there is paucity of studies in literature that are associated with the assessment of the macular thickness with Spectral Domain/ Stratus OCT and the evaluation of relationship between various macular alterations and specific characteristics of the patient. Therefore, the present study was carried out to evaluate the behaviour of central macular thickness (CMT) in patients who underwent uncomplicated cataract surgery utilizing Spectral Domain OCT. There remain unresolved issues of macular changes occurring after an uneventful cataract surgery. The aim of this study was to assess degree and pattern of changes in macula following cases of uncomplicated cataract surgery by assessment of CMT using OCT and best corrected visual acuity (BCVA) at four, eight, and twelve weeks after uncomplicated cataract surgery.

METHODS

The present study was a prospective, observational case series to measure the CMT using OCT in cases of uncomplicated cataract surgery by phacoemulsification method among patients attending eye out patient department (OPD) of a tertiary care referral hospital. Ethical permission for conducting the study was provided by the ethical committee of the institute. The present study comprised of 50 patients (50 eyes) who attended the eye OPD of this tertiary care and referral centre from July 2010 to December 2012, meeting the following inclusion and exclusion criteria.

Inclusion criteria[17]

Patients of any age or sex who underwent uncomplicated cataract surgery by phacoemulsification were chosen for the purpose of study. To avoid any confounding factors only one particular method of cataract surgery was chosen for the purpose of study.

Exclusion criteria[5]

- Patients unwilling to give consent
- Significant ocular diseases such as previous uveitis, retinopathy, and glaucoma
- History of any intra-ocular surgery except cataract/laser treatment
- Pre-existing refractive error of ≥ -6.00 D or $+6.00$ D
- Pre-existing macular edema due to any retinal pathology or epiretinal membrane
- Other posterior segment or macular pathologies
- Already using systemic steroids or topical medications (apart from lubricants)
- Cataract surgery with complications
- Media haze precluding performance of bio microscopy or OCT
- Systemic medications that may affect retinal thickening like diuretics

Collection and analysis of data

A questionnaire was administered after taking an informed consent from the patients. The questions were explained to patients by the investigator in the language they understood and relevant information was recorded (demographic data and clinical history) including

- Any history of diabetes mellitus or hypertension
- History of laser treatment of retina or any intra ocular surgery
- History of glaucoma or any known retinal disease

Clinical and ocular examination

The following detailed ocular examination was conducted on the screened patients and proforma of examination was filled for each subject:

- Best corrected visual acuity with refractive error calculation
- Slit lamp evaluation of the anterior segment

- Dilated fundus examination with direct ophthalmoscopy, 78 dioptre (D) and 90 D bio microscopy, and indirect ophthalmoscopy
- Applanation tonometry

Phacoemulsification

All patients who participated in the study underwent uneventful phacoemulsification cataract surgery. An informed consent for the surgery was obtained in all the cases. All patients were given only topical antibiotic and non-steroidal anti-inflammatory eye drops for two days prior to surgery. After dilatation of the eye to be operated with 1% tropicamide, patient was given peribulbar anaesthesia, cleaned and draped. Clear corneal temporal incision was performed with the same surgeon operating in all the cases. Oertli phacoemulsification system was used to carry out phacoemulsification and foldable intraocular lens was implanted in the bag in all the cases. The patients in which inordinately high phaco power was used or surgery were for a prolonged duration though uneventful was excluded from the study to maintain uniformity of the data and avoid any confounding. Post operatively patients were given topical steroid and antibiotic preparations in tapering doses for six weeks and non-steroidal anti-inflammatory eye drops in last two weeks.

Optical Coherence Tomography

All patients included in the study underwent OCT by Cirrus High Definition Spectral Domain (HD SD) OCT Model 4000 (Carl ZeissMeditec, Dublin, California, USA) machine and CMT for each eye was noted. An informed consent for conducting the OCT was obtained. The patient was prepared by explanation of precautions to be exercised, including strict adherence to holding the chin over the chin rest and forehead against the forehead rest during scanning. Patient identification data were entered into console and a unique patient identification created. The patient goes through minimal or no discomfort as the light used for scanning is near infrared. A sequence of axial measurements at various transverse positions was obtained in order to form a three-dimensional representation of the retina using macular cube 512 × 128. Various micro structural layers of the retina were differentiated on the basis of false color-coding system recognized by the image processing algorithm. Difference in the reflectivity of different retinal layers was attributed to their structural arrangement alongwith their biological densities and degree of pigmentation. Those structures with high biological reflectivity were represented by red, medium reflectivity with yellow/green, and those with low reflectivity were blue. Absence of a reflectivity signal was represented by black. OCT artificially divide the macula into nine regions to calculate the average retinal thickness of each region. Central retinal or foveal thickness and total volume of the macula were displayed in numerical format. It was ensured that the macular cube cross section was focused on foveal center based on maximal concavity of foveal region, which was achieved by manual alignment post OCT image capture in Cirrus HD OCT machine. This was confirmed by auto correction of nine macular regions and ascertaining the thinnest portion as foveal center which is displayed in the internal limiting membrane (ILM) RPE thickness map.

Statistical Analysis

All patients were examined by the researcher and concurred upon by a single ophthalmologist for all participants, based on the findings of ocular examination including OCT. The results of these 50 patients were collated, tabulated, analyzed and subjected to statistical analysis. Nominal data such as gender, visual acuity was presented as number (N) and percentage (%). Continuous variables (age, BCVA etc.) were presented as mean and standard deviation (SD). Chi-Square test was applied for comparison of nominal data. For continuous variable, paired t test was applied for within group comparison (e.g. day 28 v/s day 56). Additional parametric as well as nonparametric analysis of the data was performed as deemed essential. p value of < 0.05 was considered as statistically significant.

RESULTS

The present study comprised of 50 eyes of 50 patients who underwent uncomplicated cataract surgery by phacoemulsification method. Mean age of the patients was 58 years with a range of 40-76 years. The present study comprised of 27 females and 23 males. In males, right eye was predominantly involved whereas in females left eye was mainly involved. Best corrected visual acuity (BCVA) in decimal at four, eight, and twelve weeks after uncomplicated cataract surgery was 0.891, 0.9934 and 0.9934 respectively. A statistically significant difference was observed between BCVA at day (28 v/s 56) and (28 v/s 84) respectively. However, there was no significant

difference between BCVA at day (56 v/s 84). CMT following uncomplicated cataract surgery as assessed by OCT at four, eight, and twelve weeks. No significant difference was observed when mean CMT was compared at day (28 v/s 56), (56 v/s 84), and (28 v/s 84) respectively (Table 1).

A statistically significant effect of BCVA was observed on CMT post operatively at day 28 and day 56 respectively. However, there was no significant effect of BCVA on CMT at day 84 post operatively (Table 2).

A significant difference was observed between mean CMT less than 270 microns and more than 270 microns at day 28. However, p-value cannot be calculated between mean CMT less than 270 microns and more than 270 microns at day 56 (Table 3). There was no significant effect of age on CMT at post op day 28, 56, and 84 respectively (Table 4).

It was hereby seen that average BCVA improves as time increases after uncomplicated cataract surgery.

DISCUSSION

Advanced age is one of the documented risk factors for the development of Irvine-Gass syndrome or pseudophakic CME. However, in our study the mean age of patients was

Table 1: Best corrected visual acuity (BCVA) and central macular thickness (CMT) as assessed by optical coherence tomography (OCT) at 04, 08 and 12 weeks after uncomplicated cataract surgery

		Day 28 (4 weeks)	Day 56 (8 weeks)	Day 84 (12 weeks)	p value
BCVA (decimal)	Mean ± SD (Range)	0.891±0.16 (0.5-1)	0.9934±0.047 (0.67-1)	0.9934±0.047 (0.67-1)	Day 28 v/s 56 = 0.000018 Day 56 v/s 84 = 1, Day 28 v/s 84 = 0.000018
CMT (microns)	Mean ± SD (Range)	227.38±28.33 (170-300)	227.44±23.55 (178-280)	227.76±19.17 (186-260)	Day 28 v/s 56 = 0.96 Day 56 v/s 84 = 0.78 Day 28 v/s 84 = 0.86

Table 2: Effect of best corrected visual acuity (BCVA) on central macular thickness (CMT) at various stages after uneventful cataract surgery

CMT	BCVA at day 28			BCVA at day 56		BCVA at day 84	
(microns)	**6/12**	**6/6**	**6/9**	**6/6**	**6/9**	**6/6**	**6/9**
N	1	34	15	49	1	49	1
Mean ± SD	300	224.47±24.72	229.13±31.09	226.37±22.52	280.00	227.16±18.89	257.00
Range	–	170-265	180-280	178-267	–	186-260	–
p value		0.027		0.023		0.125	

Table 3: Comparison of patients with central macular thickness (CMT) less than 270 microns versus more than 270 microns at various stages after cataract surgery

	CMT at day 28		CMT at day 56	
	< 270 microns	**> 270 microns**	**< 270 microns**	**> 270 microns**
N	48	2	49	1
Mean	224.77	290.00	226.37	280.00
SD	25.66	14.14	22.52	–
p value	0.001		–	

Table 4: Effect of age on central macular thickness (CMT) of patients postoperatively in various age groups

Age (years)	CMT at Day 28 (microns)			CMT at Day 56 (microns)			CMT at Day 84 (microns)		
	Mean±SD	Range	p value	Mean±SD	Range	p value	Mean±SD	Range	p value
40-50 (n=6)	212.33±34.86	170-256		225.00±27.32	190-259		227.17±20.93	194-250	
51-60 (n=7)	239.71±36.17	188-300	0.36	234.71±29.71	190-280	0.82	229.00±20.95	197-257	0.99
61-70 (n=26)	229.00±24.48	190-280		227.54±20.55	194-261		228.15±18.54	196-260	
>70 (n=11)	223.91±27.89	180-266		223.91±26.53	178-267		226.36±21.33	186-259	
Total (n=50)	227.38±28.32	170-300		227.44±23.55	178-280		227.76±19.17	186-260	

58 years which was not advanced. The maximum CMT was found in the age group 51-60 years in our study at various intervals after cataract surgery, however, the result was not statistically significant ($p>0.05$). The sex distribution of patients was slightly more in favour of females which was not consistent with published literature that showed no predilection for either sex. Only one out of 50 patients (2%) developed both clinically suggestive and OCT confirmed CME at one, two and three months post uneventful cataract surgery with some degree of visual loss which progressively improved with time (Figure1).

It is slightly more than published literature for CME after uneventful cataract surgery (1.4%)[18-20] but less than OCT detected CME (41%).[21] This may be due to smaller sample size in our study. It is possible that pre and post-operative application of topical non-steroidal anti-inflammatory drugs was responsible for very less incidence of post-operative CME in our study. Hence, use of topical NSAID's pre and post operatively might be helpful in preventing CME development after an uneventful cataract surgery. The CMT was evaluated and compared at one, two, and three months after cataract surgery. The baseline normal value in Indian population has been calculated by Tewari et al.[12] The average foveal thickness in the population was 149.16 ± 21.15 microns using optical coherence tomographer 3 (model 3000, Humphrey-Zeiss medical system, San Leandro, CA). This was a time domain OCT and the software required were from older generations, usually producing large number of artifacts. However, these figures were still lower than the published data using similar machines worldwide. The SD-OCT measures the CMT to be approximately 50 microns higher than TD-OCT.[14] Using the upper limit of the findings of Tewari et al[12], a safe limit of 220 microns can be assumed for Indian population. The CMT was found to have slightly increased at one-two and three months post uneventful cataract surgery by phaco-emulsification but not statistically significant ($p>0.05$). The average CMT in our study was slightly above upper limit of findings of Tewari et al study.[12] BCVA increased as more time passed after cataract surgery. This is in concordance with the published literature which says it experiences spontaneous improvement by three to twelve months.[22] Two out of 50 patients (4%) were found to be having mean CMT more than 270 microns at one month after cataract surgery (statistically significant) however only one out of 50 patients (2%) had mean CMT > 270 microns at two months after surgery. In the present study, a statistically significant increase in BCVA was observed with increase in CMT at one and two months after cataract surgery. Although, BCVA increased in our study with increase in CMT at three months interval but relationship was not statistically significant. This points towards the fact that BCVA is not only dependent on CMT but also on health of proprioceptors as well. That's why despite increase in CMT the visual acuity improved in subsequent follow ups.

No other macular changes like epiretinal membranes or features of age-related macular degeneration or macular hole were found in OCT in our study which are other potential causes of diminution of vision after an uneventful phacoemulsification cataract surgery.

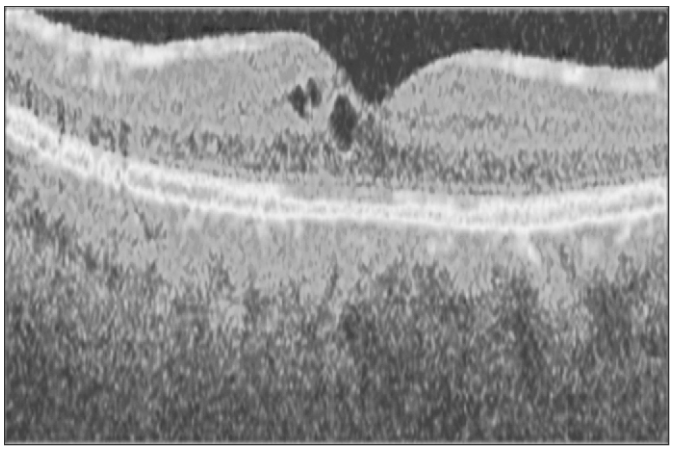

Figure 1: Optical coherence tomography (OCT) of a patient at day 28 post cataract surgery, CMT = 300 μm, cystic spaces.

In our study, the follow up was up to three months after surgery and a total of 50 patients were studied, however, an increased sample size should be taken into consideration and to determine the macular consequences patient should be followed up for longer duration. Also, various other treatment protocols should be studied in randomized controlled fashion.

CONCLUSION

Development of CME is one of the most important factors responsible for poor visual recovery after an uncomplicated cataract surgery. OCT is a useful non-invasive diagnostic tool for early detection of subclinical CME and confirmation of the same or clinically suspected CME after uncomplicated cataract surgery. There is paucity in literature especially Indian studies that assess the behaviour of the macular thickness with Spectral Domain/Stratus OCT. Keeping in view the observations of present study it can be inferred that Spectral Domain/ Stratus OCT is a useful, non-invasive diagnostic tool in assessing the macular changes in uncomplicated cataract surgery in Indian patients..

REFERENCES

1. Sourdille P, Santiago PY. Optical coherence tomography of macular thickness after cataract surgery. Cataract Refract Surg1999 ;25:256-61.
2. Van Velthoven ME, Van der Linden MH, De Smet MD, Faber DJ, Verbraak FD. Influence of cataract on optical coherence tomography image quality and retinal thickness. Br J Ophthalmol 2006;90:1259-62.
3. Nicholas S, Riley A, Patel H, Neveldson B, Purdie G, Wells AP. Correlations between optical coherence tomography measurement of macular thickness and visual acuity after cataract extraction. Clin Exp Ophthalmol 2006 ;34:124-29.
4. Biro Z, Balla Z, Kovacs B. Change of foveal and perifoveal thickness measured by OCT after phacoemulsification and IOL implantation. Eye 2008;22:8-12.
5. Ching HY, Wong AC, Wong CC, Woo DC, Chan CW. Cystoid macular oedema and changes in retinal thickness after phacoemulsification with optical coherence tomography. Eye 2006;20:297-303.
6. Podoleanu AG, Rosen RB. Combination of techniques in imaging the retina with high resolution. Prog Retin Eye Res 2008;27:464-99.
7. Srinivasan VJ, Witkowski M, Witkin AJ, Duker JS, Ko TH, Carvalho M et al. High definition and 3D imaging of macular pathologies with high speed ultrahigh-resolution optical coherence tomography. Ophthalmology 2006;113: 2054-65.
8. Schuman JS, Puliafito CA, Fujimoto JG. Optical coherence tomography of ocular diseases, 2nd edition. Thorofare, NJ: Slack Inc, 2004.
9. Kim BY, Smith SD, Kaiser PK. Optical coherence tomographic patterns of diabetic macular edema. Am J Ophthalmol 2006;142:405-12.
10. Wong AC, Chan C, Hui S. Relationship of gender, body mass index and axial length with central retinal thickness using optical coherence tomography. Eye 2005;19:292-97.
11. Chan A, Duker JS, Ko TH, Fujimoto JG, Schuman JS. Normal macular thickness measurements in healthy eyes using stratus optical coherence tomography. Arch Ophthalmol 2006;124:193-98.
12. Tewari HK, Wagh VB, Sony P, Venkatesh P, Singh R. Macular thickness evaluation using the optical coherence tomography in normal Indian eyes. Indian J Ophthalmol 2004;52(3):199-204.
13. Goebel W, Franke R. Photography. Retina 2006 ;26:49-57.
14. Querques G, Forte R, Berboucha E, Martinelli D, Coscas G, Soubrane G et al. Spectral-domain versus time domain optical coherence tomography before and after ranibizumab for age-related macular degeneration. Ophthalmic Res 2011;46(3):152-59.
15. Von Jagow B, Ohrloff C, Kohnen T. Macular thickness after uneventful cataract surgery determined by optical coherence tomography. Graefes Arch Clin Exp Ophthalmol

2007; 245:1765-71.

16. Perente I, Utine CA, Ozturker C, Cakir M, Kaya V, Eren H, et al. Evaluation of macular changes after uncomplicated phacoemulsification surgery by optical coherence tomography. Curr Eye Res 2007;32:241-47.
17. Pareja Esteban J, Moreno-Arrones JP, Drake- Rodriguez-Casanova P, Gutierrez- Ortiz C, Teus Ma. Morphological macular changes after cataract surgery: Risk factors. Arch Soc Esp Opthalmol 2009;84:605-10.
18. Mentes J, Erakgun T, Afrashi F, Kerci G. Incidence of cystoid macular edema after uncomplicated phacoemulsification surgery.Ophthalmologica 2003;217:408-12.
19. Frost NA, Sparrow JM, Strong NP, et al. Vitreous loss in a planned extra capsular extraction does lead to a poorer visual outcome. Eye 1995;9:446-51.
20. Ray S, D'AMICO DJ. Pseudophakic Cystoid Macular Edema (review). Semin Ophthalmol 2002;17:167-80.
21. Conway MD, Canakis C, Livir-Rallatos C, Peyman GA. Intravitreal triamcinolone acetonide for refractory chronic pseudophakic cystoid macular edema. J Cataract Refract Surg 2003;29:27-33.
22. Shelsta HN, Jampol LM. Pharmacologic therapy of pseudophakic cystoid macular edema: 2010 update. Retina 2011;31(1):4-12.

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