

Original Research Article

Influence of cataract on image quality and macular thickness measured using spectral domain optical coherence tomography: a prospective cohort study

Vasu Kamaladevi Lathika*, Susan Prakash Minu, K. Skariah Charles

Department of Ophthalmology, Amala Institute of Medical Sciences, Amala Nagar, Thrissur, Kerala, India

Received: 04 January 2016

Accepted: 02 February 2016

***Correspondence:**

Dr. Vasu Kamaladevi Lathika,
E-mail: lathika.vk@gmail.com

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ABSTRACT

Background: Optical coherence tomography (OCT) is one of the most useful imaging techniques in the management of retinal diseases affecting the macula. Factors affecting the image quality of OCT may affect the macular thickness and hence treatment of retinal pathologies. This study was aimed to evaluate the influence of cataract on macular scans using spectral domain OCT.

Methods: The prospective study was done in 36 patients with cataract. Cataract was graded as cortical, nuclear or posterior cataracts. All patients underwent small incision cataract surgery. Pre and post-operative imaging of the macula (4 weeks after surgery) using spectral domain OCT. The signal strength and central macular thickness (CMT) measurements were made before and after the surgery and analysed statistically.

Results: The majority (66.7%) of patients had posterior cataracts. A statistically significant improvement in OCT image quality (as assessed by signal strength) was noted post operatively. This was maximum for posterior cataracts (2.9), followed by cortical cataract (1.6), while nuclear cataracts had the least increase in signal strength (1.3). The difference in signal strength gain between posterior and nuclear cataracts was found to be statistically significant ($p = 0.05$). The increase in CMT was clinically significant only in 8.2% of the study population. No patient with nuclear cataract had a clinically significant increase in CMT following surgery.

Conclusions: Cataract can influence OCT image quality as well as central macular thickness measurements. Both were found to be affected maximally by posterior cataracts, followed by cortical, while nuclear cataracts had the least influence.

Keywords: Central macular thickness, Cataract, Optical coherence tomography, Retinal pathologies

INTRODUCTION

Optical coherence tomography (OCT) is a non-invasive, precise imaging technique that uses infrared rays to give accurate quantitative and qualitative information of the different layers of the retina. It has revolutionized the diagnosis and treatment of retinal pathologies including diabetic retinopathy and age related macular degeneration. Pupil size, refractive status, clarity of

ocular media and dryness of ocular surface are some of the factors known to influence image quality in OCT.^{1,2} Cataract being one of the leading causes of blindness in the world, contributes significantly to haziness of media which can affect OCT imaging.^{3,4} Moreover, many of the retinal vasculopathies and degenerations requiring OCT occur more frequently in the elderly population, who are likely to have concurrent cataract. A better knowledge about the type of cataracts that can hamper the quality of scans can help clinicians identify cases where OCT has to

be interpreted with caution. Studies in this regard are few, mainly done in the western population and mostly focus on retinal nerve fibre thickness in optic disc scans.⁵ Here in lies the relevance of the present study which aims to throw light on the exact influence of cataract morphology on the quality of OCT images of the macula, in Asian Indian population.

This aim of the study was to evaluate the influence of different grades of cataracts on signal strength of spectral domain OCT images of the macula. Furthermore, the study also aimed to analyse the changes in central macular thickness (CMT) measurement following cataract extraction in different grades of cataract. The results may contribute to the ultimate goal of establishing a relationship between the type of cataract, signal strength and central macular thickness measurement using SD OCT that may enable clinicians to predict and correct for cataract induced changes in these measurements.

METHODS

A prospective study of 36 patients who were posted for cataract surgery in the department of Ophthalmology, Amala Institute of Medical Sciences, Kerala, India during the study period from September 2014 to November 2014. Patients with concurrent conditions which could influence OCT signal strength like pre existing opacities of ocular media other than cataract or high refractive errors were excluded. Patients with known macular pathologies were also excluded as these could influence changes in central macular thickness. The study was approved by the institutional ethics committee.

All patients who were being planned for cataract surgery during the study period were approached and invited to participate in the study after obtaining informed consent. These patients underwent preoperative cataract work up including best corrected visual acuity (BCVA) measured using Snellen chart, a complete dilated slit lamp evaluation, bio microscopic examination of fundus using 90D lens, assessment of IOL power, tonometry and syringing.

Cataract was assessed and graded depending on the highest score using the lens opacities classification system III (LOCSIII) scoring system.⁶ If the score was >NO3–NC3 and <C3 and P3, the cataract was grade as nuclear. If the score was >C3 it was graded as cortical and if it was >P3 it was considered posterior. If the score was <NO3–NC3, the highest C or P score was used to grade the cataract. Thus, based on LOCS scores, patients were divided into three groups.

- Those with predominantly posterior cataract
- Those with nuclear cataract
- Those with cortical cataract

Spectral domain OCT images of macula of all patients were obtained preoperatively through dilated pupils using CIRRUS HD-OCT (Carl Zeiss, Germany), using the macular cube mode. The data was obtained from a three-dimensional dataset composed of 512 A-scans derived from 128 B-scans that cover a 6 × 6 mm area centered on the fovea. All patients underwent uncomplicated small incision cataract surgery. Postoperative regimen included oral antibiotics, topical antibiotics, anti-inflammatory and steroid drops. OCT scans were repeated during follow up visit, one month after surgery.

Signal strength is known to be a reliable indicator of image quality in spectral domain OCT.⁷ Hence, in order to assess image quality difference after cataract surgery, signal strength of the preoperative and post operative OCT images were recorded and difference noted. Central macular thickness values before and after surgery were also noted.

The data was subjected to statistical analysis using SPSS (v23, IBM, CA, USA). Paired t test was used to determine the influence of grade of cataract on OCT signal strength and CMT measurement before and after cataract surgery. Further comparison analysis between the grades of cataract was done using independent sample t test. A p-value of less than 0.05 was taken as statistically significant.

RESULTS

Of the 36 eyes included in the study, majority had posterior cortical cataract (20/36). There were eight eyes with nuclear and eight with cortical cataract.

Cataract and OCT image quality

The OCT image quality as assessed by signal strength improved following cataract surgery (Table 1). The mean OCT signal strength of the group preoperatively was 4.91, which improved to 7.19 postoperatively. This difference of 2.27 was found to be statistically significant ($p = 0.0001$). Subgroup analysis of each grade of cataract showed that signal strength improved following cataract surgery in all grades of cataract to a statistically significant extent (Table 2). The gain in OCT signal strength post operatively was maximum for posterior cataracts (2.9, $p=0.0001$), followed by cortical cataract (1.6, $p=0.024$), while nuclear cataracts had the least increase in signal strength (1.3, $p = 0.028$). Of these, the difference between posterior and nuclear cataracts was found to be statistically significant ($p = 0.05$) using the independent sample t-test (Table 3).

Cataract and central macular thickness measurements

It was analysed whether cataract affected CMT measurements by noting the difference in values between pre-operative and post-operative OCT scans. Like OCT signal strength, the average CMT of the study group was

also found to increase following cataract surgery. The mean preoperative CMT was 247.667 microns which increased to 256.417 four weeks after surgery. Thus there was a mean increase of 8.7 microns in mean CMT of the

study group postoperatively, which amounted to a percentage increase of 3.48% from the baseline pre operative mean CMT (Table 4).

Table 1: Comparison of mean optical coherence tomography (OCT) signal strength of the study group before and after cataract surgery.

Mean OCT signal strength of study group	Mean SS difference	N	Standard deviation	Std. error mean	P value*
Pre operative-4.917	2.27	36	1.6966	0.2828	0.0001
Postoperative-7.194		36	1.4894	0.2482	

Paired t test.

Table 2: Comparison of signal strength difference before and after cataract surgery in different grades of cataract.

Cataract grade	Mean signal strength difference	N	Std. deviation	P value*
Cortical	1.6	8	1.6850	0.024
		8	2.0529	
Nuclear	1.3	8	1.1952	0.028
		8	1.0607	
Posterior	2.9	20	1.8468	0.0001
		20	1.3179	

*Independent sample t test.

Table 3: Comparison of mean optical coherence tomography (OCT) signal strength difference before and after cataract surgery between the different grades of cataract.

A: posterior cortical and nuclear.

Grade of cataract	N	Mean OCT SS difference	Std. deviation	Std. error mean	P value*
Posterior	20	2.900	1.9708	0.4407	0.058
Nuclear	8	1.375	1.4079	0.4978	

B. Posteriorcortical and cortical.

Grade of cataract	N	Mean OCTSS difference	Std. deviation	Std. error mean	P value
Posterior	20	2.900	1.9708	0.4407	0.117
Cortical	8	1.625	1.5980	0.5650	

C. Cortical and nuclear.

Grade of cataract	N	Mean SS difference	Std. deviation	Std. error mean	P value
Nuclear	8	1.375	1.4079	0.4978	0.745
Cortical	8	1.625	1.5980	0.5650	

*Independent sample t test

This difference was found to be statistically significant (p = 0.007, paired t test). However, only 8.2% of the study population showed clinically significant increase in CMT (more than 10% from pre-operative baseline scan was

taken as clinically significant) on repeat OCT scans 4 weeks post operatively (Figure 1).⁸

Analyzing the distribution of cataracts in eyes where such a significant increase was detected, we found that

majority (66.7%) were eyes with posterior cataracts, while 33.3% were cortical cataracts (Figure 2). No patient

with nuclear cataract had a clinically significant increase in CMT following cataract surgery.

Table 4: Change in central macular thickness (CMT) before and after cataract surgery (4 weeks post surgery).

N	Mean CMT	Standard deviation	Mean CMT difference	% CMT increase wks	P value*
36	Pre-operative-247.667 microns	25.19	8.7 microns	3.48	0.007
	Postoperative-256.417 microns	18.15			

*Independent sample t test.

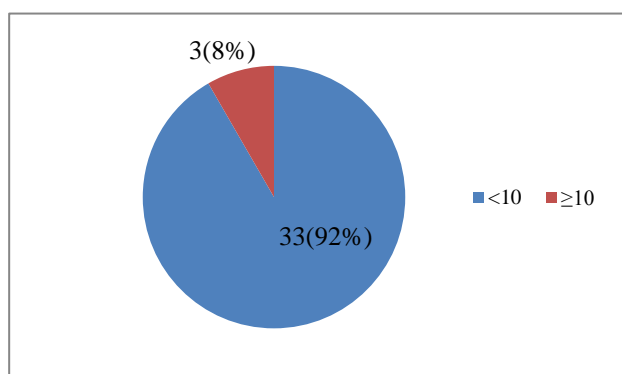


Figure 1: Percentage distribution of clinically significant increase in central macular thickness (by >10%) in the study group 4 weeks post operatively.

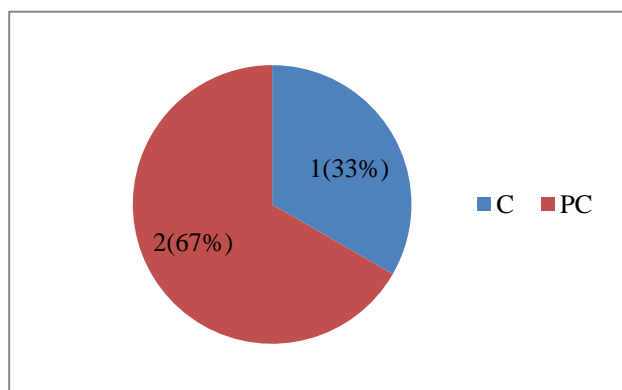


Figure 2: Distribution of cataracts in the group with clinically significant increase in post operative central macular thickness.

DISCUSSION

Our study showed that SD OCT signal quality as assessed by signal strength of macular scans improved to a statistically significant extent following cataract surgery ($p = 0.0001$), implying that cataract does affect clarity of macular scan image acquisition. This observation is in concurrence with the study by Velthovan et al who found that SD OCT image quality was influenced by the cataracts.⁹ However, a study by Na JH et al found that cirrus OCT scan quality varied with cataract only in optic

disc mode and not in macular scan acquisition mode.³ This could be due to the younger average age and milder cataracts in their study compared to ours.

Further analysis revealed that posterior cataracts affected signal strength maximum followed by cortical and then nuclear. Of these, the difference between posterior and nuclear cataracts was found to be statistically significant. Literature review suggests that this could be due to nuclear cataracts causing only infrared absorption and not much light scattering.⁹ So, though this may cause the back reflected signal to be less intense, it does not distort the light beam. In contrast, it is hypothesised that posterior cortical cataracts or cortical cataracts close to visual axis, affect the incident and back-reflected light beams more by scattering, thus distorting the OCT image early on.

Studies have shown significant differences in CMT with improving OCT signal strength, with absolute variations of around 5 microns for macular scans.¹⁰ Our study found that when measured four weeks after cataract extraction, there was a mean increase of 8.7 microns in central macular thickness, which amounted to a percentage increase of 3.48% from the baseline pre-operative mean central macular thickness. This was statistically significant ($p = 0.007$). But, a clinically significant increase of more than ten percent from baseline CMT occurred only in 8.3% of the study population.

Though increase in macular thickness following cataract extraction is well documented, literature is limited on the influence of the grade of cataract upon CMT measurement using SD OCT.¹¹ Hence, we further analysed the type of cataracts which showed a clinically significant difference of more than 10% from baseline in macular thickness one month following cataract extraction. Our study revealed that all such patients had either cortical (50%) or posterior (50%) cataracts. No patient with nuclear cataract showed a significant increase in central macular thickness after cataract surgery. This fact could be explained by our earlier observation that nuclear cataracts were found to have minimal effect on OCT image quality/signal strength too. Our observations concur with the study by Van

Velthoven et al which showed that OCT measurements can differ after removal of the cataract, more so in predominantly posterior cataracts.⁹

CONCLUSION

Cataract surgery resulted in a statistically significant increase in both signal strength and central macular thickness measured using macular scan mode of spectral domain OCT. However, the increase in central macular thickness was clinically significant in only a small percentage of the study group (8.3%), majority of whom had posterior cataracts. The improvement in OCT signal strength and clinically significant increase in central macular thickness were maximum following removal of posterior cataracts, followed by cortical and nuclear cataracts. Hence it is recommended that macular thickness variations measured using SD OCT should be interpreted with caution, more so in patients who have undergone extraction of posterior cataracts, as compared to nuclear cataracts.

ACKNOWLEDGEMENTS

Authors would like to thank Mrs. Gini, Assistant Professor of Statistics and Mr. Vidhu M. Joshi, Biostatistician, Department of Community Medicine, Amala Institute of Medical Sciences, Amala Nagar, Thrissur, Kerala, India for the valuable help with statistical analysis.

Funding: No funding sources

Conflict of interest: None declared

Ethical approval: The study was approved by the institutional ethics committee

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Cite this article as: Lathika VK, Minu SP, Charles KS. Influence of cataract on image quality and macular thickness measured using spectral domain optical coherence tomography: a prospective cohort study. *Int J Adv Med* 2017;4:546-50.