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Central Macular Thickness in Uneventful Phacoemulsification Employing Optical Coherence Tomography

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ABSTRACT

Introduction

Cataract is the most common cause of blindness affecting the global population which can be cured by phacoemulsification surgery. The study aimed to evaluate the central macular thickness following uneventful phacoemulsification surgery and analyze its relation to various factors.

Methods

This prospective study comprised of 63 subjects diagnosed as age-related cataract on the basis of lens opacities classification system III and undergoing uneventful phacoemulsification surgery with capsular bag intraocular lens implantation. The central macular thickness was evaluated using optical coherence tomography at preoperative period and postoperatively on 1st day, 1st week and 5th week. Effective phacoemulsification time was measured intraoperatively.

Results

The mean effective phacoemulsification time was 17.95±14.01 seconds. Best corrected visual acuity improved significantly postoperatively (p=0.03). Mean central macular thickness increased significantly on the 5th postoperative week compared to preoperative assessment (p=0.002). No significant association was detected between patient's age and preoperative and postoperative central macular thickness. No correlations were observed between effective phacoemulsification time and central macular thickness. Significant association was not noted between central macular thickness and best corrected visual acuity on pre and postoperative examinations.

Conclusion

There was a decrease in central macular thickness on the 1st day and 1st week postoperatively followed by a significant increase on the 5th postoperative week compared to the preoperative period, which was independent of effective phacoemulsification time. Increase in central macular thickness in the postoperative period did not affect the quality of vision.

Keywords

Central macular thickness, effective phacoemulsification time, optical coherence tomography, phacoemulsification

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INTRODUCTION

Cataract is the leading cause of blindness with an estimation of 41.8% of all global blindness.[1] It is also among the major causes of blindness in Nepal, accounting for more than 80% of all avoidable blindness in nearly every geographical area and demographic group.[2] Phacoemulsification, which was initially described by Kelman in 1967 is now considered a well-established method of cataract surgery with excellent visual outcomes and reduced surgically induced astigmatism.[3,4] However, different surgical steps and parameters of phacoemulsification including fluidics and ultrasonic energy can cause instantaneous pressure fluctuation leading to direct effects on various tissues in the eyeball.[5] As excessive transudate accumulates within the retina leading to breakage of blood retinal barrier due to change in fluidics or ultrasound energy used during emulsification of the nucleus. Also, macular region is predisposed to the collection of fluid by the virtue of its anatomic structure as the horizontal course of the transversely arranged outer plexiform layer. The resultant laxity of this layer along with the avascularity of the foveola restricts the absorption of transudate, and thus predisposes to accumulation of fluid and a concomitant increase in macular thickness.[6,7]

The objective of the study is to determine the effects of uneventful phacoemulsification on central macular thickness (CMT) and visual acuity along with the relation of CMT to effective phacoemulsification time (EPT). Uneventful phacoemulsification implies to the surgeries without any intraoperative or postoperative complications such as wound site leak, posterior capsule rent, vitreous loss, etc. This study also aims to establish the correlation between preoperative as well as postoperative CMT with regard to age, gender, and geographical residence and ethnicity.

METHODS

This was a hospital-based prospective study that included 63 subjects (63 eyes) with age related cataract (ARC) who underwent uneventful phacoemulsification with intraocular lens implantation (IOL) implantation from April 2018 to August 2019 at Bharatpur Eye Hospital, performed by a single surgeon. The study was approved by the Institutional Review Board, National Academy of Medical Sciences, Bir Hospital. This study adheres to the tenets of Declaration of Helsinki and informed written consent was obtained from all patients prior to their enrollment in this study.

Participants fulfilling the inclusion criteria were enrolled in the study, which comprised patients diagnosed as ARC with absence of any underlying ocular or systemic comorbidities. Patients with (1) macular or retinal pathologies such as epiretinal membrane, macular holes, age-related macular degeneration, retinal vascular occlusion or retinal dystrophy, (2) ocular comorbidities such as glaucoma, uveitis or vitreous hemorrhage, (3) other forms of cataract other than ARC, (4) systemic disease such as diabetes that could affect the eye, (5) high refractive error or amblyopia, (6) mature cataract or dense posterior subcapsular cataract where Optical Coherence Tomography (OCT) could not be performed, (7) patients under topical medication or systemic medication with known interference on retinal thickness were excluded. ARC was classified on the basis of lens opacities classification system III (LOCS III).[8]

All included cases were subjected to detailed history taking, general physical examination, thorough ocular examination inclusive of anterior and dilated posterior segment examination using a slit lamp biomicroscope (Inami.co ltd, Tokyo, Japan) and volk 90 D lens, investigations namely intraocular pressure (IOP) measurement using noncontact tonometry, axial length measurement, IOL power calculation, CMT measurement using Spectral Domain Optical Coherence Tomography (SD-OCT) (TOPCON 3D OCT, 2000 series, Tokyo, Japan).

Surgeries were performed under peribulbar (5 ml of xylocaine 2%)/ topical anesthesia (proparacaine 0.5%). Gtt ciprofloxacin 0.3% was instilled four times a day, one day prior to surgery in all cases as a standard institutional protocol. Mydriasis was achieved using gtt tropicamide 0.8% and phenylephrine 5%, one hour prior to the surgery. Peribulbar or topical type of anesthesia, laterality of the operated eye, and EPT were recorded intraoperatively.

Under all aseptic precautions, a 2.8 mm clear corneal incision was made just anterior to the vascular arcade of the corneoscleral limbus using the keratome. Paracentesis incision of one mm was made 60° apart with a 15° side-port blade. Continuous curvilinear capsule-rhexis (5.5 to 6mm), hydro-dissection, and nucleus rotation were carried out sequentially. Phacoemulsification (Oertli, Faros, Switzerland) was applied to emulsify the cataract using stop and chop technique followed by aspiration of cortical matter with coaxial irrigation and aspiration canula and a foldable hydrophilic IOL was implanted within the capsular bag. Intracameral moxifloxacin (100µgm/ml) was given followed by subconjunctival gentamycin(20mg/ml) and dexamethasone(4mg/ml) along with topical application of eye ointment polymyxin B sulphate 1000 units, chloramphenicol 10mg and dexamethasone sodium phosphate 1mg. Eye padding was continued until removal on the 1st postoperative day (POD).

Every patient received a standard postoperative regime of Gtt moxifloxacin 0.5% and Gtt

Table 1. Descriptive statistics of the main parameters

Parameters	Frequency (%)
Gender	
Male	24 (38.1%)
Female	39 (61.9%)
Geographical region	
Hilly	8 (12.7%)
Mountain	7 (11.1%)
Terai	48 (76.2%)
Laterality of Eyes	
Right eye	32 (50.8%)
Left eye	31 (49.2%)
Type of Anesthesia	
Topical	28 (44.4%)
Peribulbar	35 (55.6%)
BCVA (log MAR± SD)	
Preoperative	0.658±0.27
1st POD	0.246±0.14
1st week	0.178±0.12
5th week	0.125±0.10
Mean EPT (seconds)	17.95±14.01 (3-59)

prednisolone acetate 1% in a tapering manner for five weeks. Patients were examined for five weeks postoperatively where best corrected visual acuity (BCVA), IOP, and CMT were measured (preoperative, 1st POD, 1st week and 5th week) following the surgery.

For statistical purposes, BCVA measured using the Snellen chart were converted to the logarithm of the minimal angle of resolution (log MAR). Data was entered and analyzed using IBM SPSS software.

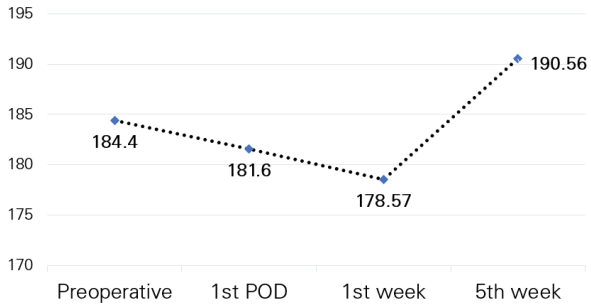

Figure 1. Mean CMT in pre and postoperative duration

Frequencies and percentages were computed to describe the categorical variables. Paired t test was used to compare mean pre- and postoperative CMT. Unpaired t-test was used to correlate CMT with gender and EPT. One Way ANOVA (analysis of variance with repeated measurements), was used to compare CMT in relation to age, geographic residence, ethnicity, pre- and postoperative BCVA. p-value <0.05 was considered significant.

RESULTS

Our study comprised of 63 eyes of 63 subjects with a mean age of 65.73±9 years (45-88 years) undergoing uneventful phacoemulsification surgery with capsular bag IOL implantation more on peribulbar (55.6%;35 eyes) anesthesia with EPT of 17.95±14.01 seconds (3-59 seconds). Right eye was operated slightly more (50.8%; 32 eyes) than the left eye. Baseline parameters are summarized in Table 1. BCVA at the preoperative period was 0.658±0.27 logMAR, which markedly improved to 0.125±0.10 logMAR on the 5th postoperative week (p=0.003).

The mean CMT at the preoperative period

Table 2. Comparison of CMT pre and postoperatively

CMT (µm)		Mean difference (µm)	p-value*	Correlation (r)+
Preoperative 184.40±20.47	1st POD 181.40±19.80	-3	0.001	0.75
	1st week 178.57±18.56	-5.83	0.001	0.86
	5th week 190.56±43.92	6.16	0.002	0.39
1st POD 181.40±19.80	1st week 178.57±18.56	-2.83	0.001	0.87
	5th week 190.56±43.92	9.16	0.002	0.38
1st week 178.57±18.56	5th week 190.56±43.92	11.99	0.001	0.47

Paired T Test; Pearson Correlation+*
CMT: central macular thickness; POD: postoperative day

Table 3. CMT in relation to age, gender, geographic region, ethnicity, EPT

Characteristics	Groups	Number	CMT (µm)							
			Preoperative	p-value	1st POD	p-value	1st Week	p-value	5th Week	p-value
Age * (years)	40-50	2	172±4.23	0.53	167±11.31	0.47	166±9.19	0.38	177.5±10.60	0.94
	50-60	15	187.07±16.24		179.87±13.64		179.4±16.3		186.4±16.81	
	60-70	23	187.48±22.07		186±20.98		182.91±20.68		191.22±19.66	
	≥70	23	180.65±21.94		179.61±22.26		174.74±17.94		193.5±69.48	
Gender+	Male	24	195.46±21.85	0.001	193.17±20.8	0.001	189.63±19.06	0.001	208.83±65.15	0.008
	Female	39	177.5±16.42		174.4±15.5		171.77±14.75		179.31±15.43	
Geographical region*	Hilly	8	181.25±16.96	0.80	190.88±21.59	0.36	180.38±14.32	0.89	186.88±16.24	0.95
	Mountain	7	181.29±23.81		178.14±15.81		175.86±15.80		187.71±20.99	
	Terai	48	185.38±20.81		180.56±19.96		178.67±19.76		191.58±49.44	
Ethnicity*	Brahmin	18	180.83±22.5	0.79	178.39±20.84	0.85	177.11±21.04	0.66	184.78±21.50	0.36
	Chhetri	11	193.00±28.9		188.64±23.17		187.91±24.48		221.36±95.96	
	Gurung	4	181.50±20.8		179.25±17.32		177.25±16.95		186.25±22.27	
	Newar	6	177.83±13.87		177.33±10.57		171.33±9.87		179.50±10.76	
	Tamang	2	187.50±17.67		181.50±9.19		179.50±9.19		188.50±14.95	
	Tharu	6	184.67±10.87		177.33±11.96		173.67±11.03		181.0±14.22	
	Others	16	185.19±17.14		184.19±23.43		178.56±17.02		184.94±15.63	
EPT+ (seconds)	≤ 25	50	181.66±19.22	0.10	180.36±20.21	0.36	176.90±18.39	0.14	184.16±17.91	0.001
	26-50	10	193.30±21.54		183.20±14.65		181.0±14.31		188.40±17.07	
	≥ 50	3	200.33±29.67		197.00±27.87		198.33±28.04		304.33±173.70	

**One Way ANOVA*
+Unpaired T test
CMT: central macular thickness
POD: postoperative day

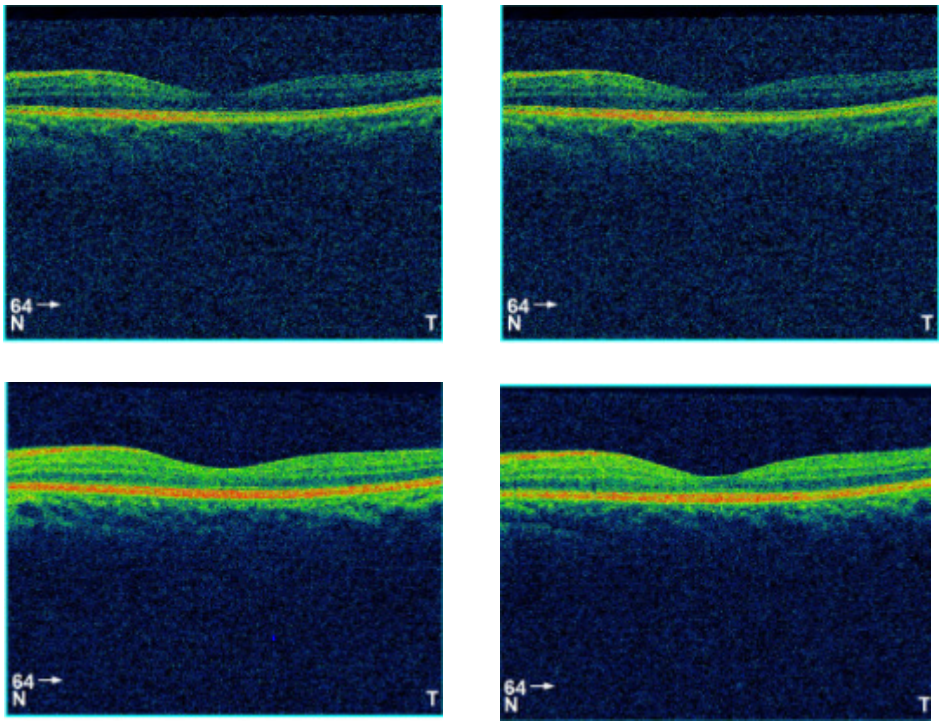

Figure 2. CMT on pre- and various postoperative days. A. Preoperative CMT (266.9μ) B.1st POD CMT (265.0 μ) C.1st Postoperative week CMT (263.4 μ) D. 5th Postoperative week CMT (275.4 μ)

was measured to be 184.40±20.47μm, which significantly increased to 190.56±43.92μm (p <0.002) on the 5th postoperative week (Table 1, Figure 1).

Measurement of CMT is shown in Figure 2. The comparison between pre- and postoperative CMT is shown in Table 2. CMT was significantly increased postoperatively at 5th week. No correlation has been observed between pre- and postoperative CMT.

Association of CMT with age, gender, geographic region, ethnicity, and EPT is shown in Table 3. No significance was observed in CMT with respect to age, geographic region, ethnicity, and EPT. However, it is associated significantly with gender of the subjects. Significant association of CMT with BCVA is not perceived in pre- and postoperative assessments. No correlation was noted between CMT and BCVA as shown in Table 4.

Table 4. Correlation between BCVA and CMT

BCVA Vs. CMT	p-value*	Correlation (r)+
Preoperative	0.24	-0.150
1st POD	0.77	0.038
1st Postop week	0.06	-0.242
5th Postop week	0.80	0.032

+Pearson Correlation
BCVA: best corrected visual acuity; CMT: central macular thickness; POD: postoperative day

DISCUSSION

Phacoemulsification is often associated with visual-threatening postoperative complications like pseudophakic cystoid macular edema (PCME), which is frequently seen 4–6 weeks after surgery usually resolves spontaneously persisting only in about 1–3% of cases, corresponding to clinical PCME.[9,10] Although the exact pathogenesis is not known, the role of inflammatory and mechanical alterations of vitreoretinal structures, surgical trauma, and release of prostaglandin may cause increased permeability of the perifoveal capillaries resulting in increased macular thickness and subsequently severely decreased postoperative VA.[11,12,13]

Fundus fluorescein angiography, although being the gold standard method for diagnosing cystoid macular edema, is invasive and qualitative.[14] OCT is a noncontact, noninvasive, quantitative, and reproducible technique that can achieve a cross-sectional measurement of retinal thickness up to 10μm, detecting subtle changes in retinal thickness is thus used commonly.[7,15] OCT changes of postoperative macular thickness were observed after 5th postoperative weeks in different studies.[16,17]

Studies conducted by Perente et al[18] (p <0.05) showed a significant increase in CMT at the 5th postoperative week, while Knez et al [19] (p ≤0.008), Gharbiya et al[20] (p <0.0001), Biro et al.[16] (p <0.05), Eriksson et al[21], Kim et al[22] and Degenring et al[23] observed significant increase in macular thickness 1 month after surgery. This result is

similar to our study as there is decrease in 1st POD and 1st postoperative week CMT compared to preoperative, although there is significant increase in 5th postoperative week. Apparent reduction of macular thickness could be related to the presence of an IOL, therefore adjustments in retinal thickness measurement by OCT shall be required if the lens status has been changed.[20] Study with a longer follow-up duration of 12 months was performed by Kecik et al.[24] where a significant increase in macular thickness was detected 1 month after surgery, which remained at the same level from 3-12 month.

However, our study result differs with Ching et al. where the preoperative central retinal and foveal thickness were significantly thicker than those in the 8th postoperative week (p <0.05). Authors have explained the cause as a result of preoperative measurement error due to the presence of cataracts, apparent thinning of the retina following replacement of the crystalline lens by an IOL, and an increase in signal/noise ratio in the postoperative assessments which may be due to an increase in noise in the cataractous eye affecting the measurement of OCT.[15]

Patient age was not associated with CMT in pre- as well as postoperative period in our study (p >0.05) which is similar to the studies done by Gharbiya et al[20] Golebiewska et al[25], (p =0.1265) and Sourdille P et al[26] (p =0.579). Females (n= 39) were slightly more than male (n=24), which resonates with the studies performed by Ching et al[15], Kecik et al[24], Giansanti et al[13], Georgopoulos et al [17] and Kim et al.[22] In this study the CMT when compared with gender at preoperative as well as various postoperative periods were found to be significantly higher in males than in females (p <0.05) which is similar to the study done by Golebiewska et al.[25] (p < 0.0019). Likewise, postoperative CMT has increased significantly compared to gender (p <0.008).

Regarding the residential area, the highest participants 76.2% (n=48) were from Terai, followed by Hilly and Mountain. No significant association were found in our study between residential area and CMT on pre- and postoperative visits (p >0.05). Associations between CMT and residential areas has not been done yet in any of the published literatures, therefore our study is the first in line to define the association. This study showed no significant association with CMT and ethnic background of the participants (p >0.05). Significances between CMT and ethnic backgrounds has not been performed yet to the best of our knowledge.

Right eyes were operated slightly more 50.8% (32eyes) than left eyes 49.2% (31 eyes) which resonates with the studies conducted by Ching et al[15], Akcay et al[27], Giansanti et al[13] and Gede Pardianto et al.[5]

The mean EPT was measured to be 17.95±14.01 seconds, which is similar to the study performed by Gede Pardianto et al.[5] However, studies done by Anastasilakis et al[28] , Zhou et al[9], and Ammerer et al.[29], mean EPT was 94 ± 48.3 seconds, 38.42±17.28 seconds and 40 seconds respectively. Smaller duration of EPT in our study could be possibly explained as a result of predominant immature cataract, surgeon experience and power setting parameters.

No significance was observed between EPT and macular thickness (p >0.05) in studies executed by Pardianto et al[5], Gharbiya et al[20], von Jagow et al[30] and Biro et al.[16] which is similar to this study (p =0.149). However, there is a significant association noted between EPT and CMT on the 5th postoperative week which is not documented in any of the other studies (p =0.001) to the best of our knowledge.

Postoperative BCVA significantly improved compared to preoperative BCVA (p<0.05), which is similar to studies conducted by Pardianto et al.[5], Georgopoulos et al[17] and Degenering et al (p<0.001)[23] The improvement in postoperative BCVA could be due to replacement of the cataractous human lens with clear IOL.

Significant association was not observed in our study between CMT and BCVA on pre- and postoperative visits (p >0.05), which corresponds with the studies performed by Gharbiya et al.[20] (p >0.05), Georgopoulos et al[17] and Ching et al (p >0.07)[15]. No correlation was observed between pre- and postoperative CMT and BCVA in this study, which is similar to the studies conducted by John M. Katsimpris et al[31] and Gharbiya et al.[20]

The primary limitation of our study was the fewer number of participants along with shorter follow-up. As the study was conducted in a single center, the enrollment of the participants was challenging which could under power the results. Therefore, we recommend that this type of study shall be conducted with a larger sample size and longer follow-up duration.

CONCLUSION

Central macular thickness, increased significantly on the 5th postoperative week without any degradation of postoperative BCVA. Increased CMT could be caused by alteration of blood retinal barrier, with other possible causes being vascular instability and vitreomacular traction. BCVA distinctly improved after surgery which could be due to replacement of the cataractous human lens with IOL. Hence, surgery like phacoemulsification hold an enormous role in improving patient level of wellbeing.

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CONFLICT OF INTEREST

The author(s) declare that they do not have any conflicts of interest with respect to the research, authorship, and/or publication of this article.

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