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Effective Phacoemulsification Time and Macular Thickness Changes on Optical Coherence Tomography Following Uneventful Cataract Surgery

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Abstract: This study aimed to evaluate the effect of uneventful phacoemulsification on central macular thickness (CMT) using spectral-domain optical coherence tomography (SD-OCT) of macula and its correlation with effective phacoemulsification time (EFT) in healthy eyes. A prospective interventional, non-comparative study of 30 eyes of 28 patients who underwent uneventful cataract extraction at Research Institute of Ophthalmology, Giza Egypt between April 2015 and April 2016. The main outcome measures were EFT, pre and 1 month post-operative CMT, Best-corrected visual acuity. Results revealed that thirty eyes of 28 patients (16 males and 12 females) were included in the study with mean age of 58.57 ± 5.13 years (range: 48 – 70 years). Central macular thickness (CMT) changed from 260.40 ± 19.09 µm preoperatively (Range = 214 – 310 µm) to 279.00 ± 59.80 µm postoperatively (Range = 214 – 572 µm) with a statistically significant CMT change (p = 0.043). Effective phacoemulsification time was 5.64 ± 1.24 sec (range = 3.8 – 8.7 sec) A positive correlation was inferred between CMT change and EPT (p = 0.009). In conclusion, the risk of increased macular thickness is correlated strongly with the effective phacoemulsification time to remove the cataractous lens in uncomplicated phacoemulsification of healthy eyes.

Key words: Effective Phacoemulsification Time (EFT) · Central Macular Thickness (CMT) · Cystoid Macular Oedema (CMO)

INTRODUCTION

A cataract is a leading cause of blindness and severe visual impairment worldwide [1]. Cataract extraction is the most commonly performed surgery with National Institute of Health reporting ninety percent of operated patients reporting better vision after the surgery [2]. 'Vision 2020: Right to Sight' initiative by Word Health Organisation has therefore recommended a high quality and quantity cataract extraction programme worldwide [3].

Alongside various intra and post-operative risks, Cystoid macular oedema (CMO) is a recognised cause of unfavourable visual outcomes following uneventful cataract extraction [4, 5]. Subclinical foveal leakage is demonstrated through angiographic assessment in up to 19% or more patients after cataract surgery in some recent studies [6]. Whereas, the incidence of clinically significant CMO is still established to be around 1.4% of psuedophakic eyes despite the advancement from intra capsular cataract extraction to modern phacoemulsification techniques [7]. Phacoemulsification is now a days, the most common method of cataract extraction. Even with smaller incisions and modern fluidics, it is still considered to cause an inflammatory insult to the ocular tissue leading to the exacerbation of pre-existing retinal disorders like diabetic macular oedema (DMO) or development of newer ocular disorders like Irvin-Gass syndrome [8].

Various theories in animal models have explained the phenomenon of CMO with lens fragmentation leading to breakage of blood brain barrier and increased expression of pro inflammatory mediators like prostaglandin causing enhanced leakage within retinal and choroidal circulation [9]. Vitreomacular traction and light toxicity induced by cataract surgery has also reported to play role in CMO development [10].

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The aim of this study is to report central macular thickness (CMT) changes with the use of spectral domain optical coherence tomography (SD-OCT) following uneventful cataract surgery and exploring the correlation of effective phacoemulsification time (EFT) with CMT.

MATERIALS AND METHODS

A prospective interventional, non-comparative study of 30 eyes of 28 patients who underwent uneventful cataract extraction at Research Institute of Ophthalmology, Giza Egypt between April 2015 and April 2016.

The study was approved as a prospective audit by local institutional review board and the study adhered to the tenets of the Declaration of Helsinki. Patients between age 30 and 80 years were included in the study and cataracts were graded on Lens opacity classification system III (LOCS III). Patients with a dense cataract or corneal opacity interfering with imaging, macular pathologies like age related macular degeneration (AMD), diabetic macular oedema (DMO) or any other ocular comorbidity affecting the vision were excluded from the study. All patients had uneventful cataract extraction, any case with vitreous loss was also excluded.

All patients were assessed before surgery with detailed history of type, duration and onset of visual deterioration, records of previous documentation on ocular co morbidities and surgeries, uncorrected (UCVA) and best corrected visual acuity (BCVA), pupillary reflexes, intra ocular pressure and detailed slit lamp biomicroscopic examination. Optical coherence tomography of macula was also performed utilizing spectral domain Heidelberg OCT (Spectralis, Germany). All patients had provided written consent for the surgery.

Surgical Technique: All patients were operated under peribulbar anaesthesia. One hour before surgery the pupils were dilated with Tropicamide 1%. Periocular skin was prepped with Povidone Iodine 10% alongside irrigating conjunctival sac with Povidone Iodine 5% for 3 minutes.

Clear corneal three step wound and two side ports 90 degrees apart were made by 2.8mm disposable keratome and MVR 20 gauge blade respectively. The anterior chamber was filled with Ophthalmicvisco surgical device, OVD (Hydroxypropyl methylcellulose) and a continuous curvilinear capsulorhexis were performed using capsulorhexis forceps. Hydro-dissection performed with a flat tip canula and was utilized in rotating the nucleus. Phacoemulsification was done through sculpting (phaco 1) and then quadrant removal (phaco 2). Effective phacoemulsification time (EPT) was recorded for all cases. All cases were completed using stop and chop technique of phacoemulsification. Cortical removal was performed using bimanual irrigation and aspiration utilizing a tangential stripping method in combination with gentle centripetal movements to allow smooth removal of cortical material from the capsular bag. Capsular bag was then filled with OVD and implantation of posterior chamber intraocular lens (PCIOL) was performed followed by aspiration of OVD and anterior chamber filling with balanced salt solution (BSS) and intra cameral cefuroxime. The procedure concluded with hydrating the main wound and side ports.All patients were prescribed topical Moxifloxacin 0.5% and Prednisolone acetate 1% five times a day for two weeks and then tapered over further two weeks. At one month follow up, all patients had post-operative assessment including UCVA, BCVA, objective refraction, slit lamp biomicroscopy to assess cornea, aqueous flare or cells, intra ocular pressure, IOL position, fundus examination. A final post-operative OCT scan of the macula was also performed at this stage.

Statistical analysis was performed after collection, revision and coding using the software SPSS for Windows version 23.0 (IBM, Armonk, NY, USA). The comparison between two independent groups with quantitative data and parametric distribution was done by using an Independent t-test while the comparison between two paired groups with quantitative data and parametric distribution was done by using *Paired t-test.* The comparison between two independent groups with quantitative data and non-parametric distribution was done by using Mann-Whitney test while the comparison between two paired groups with quantitative data and parametric distribution was done by using *Wilcoxon-Rank test. Spearman correlation coefficients* were used to assess the correlation between two quantitative parameters in the same group. For all statistical tests, a p-value of less than 0.05 was considered as statistically significant.

RESULTS

Thirty eyes of 28 patients (16 males and 12 females) underwent uneventful cataract extraction during the study period at Research Institute of Ophthalmology, Giza Egypt between April 2015 and April 2016. The mean age of the patients was 58.57 ± 5.13 years (range: 48 – 70 years).

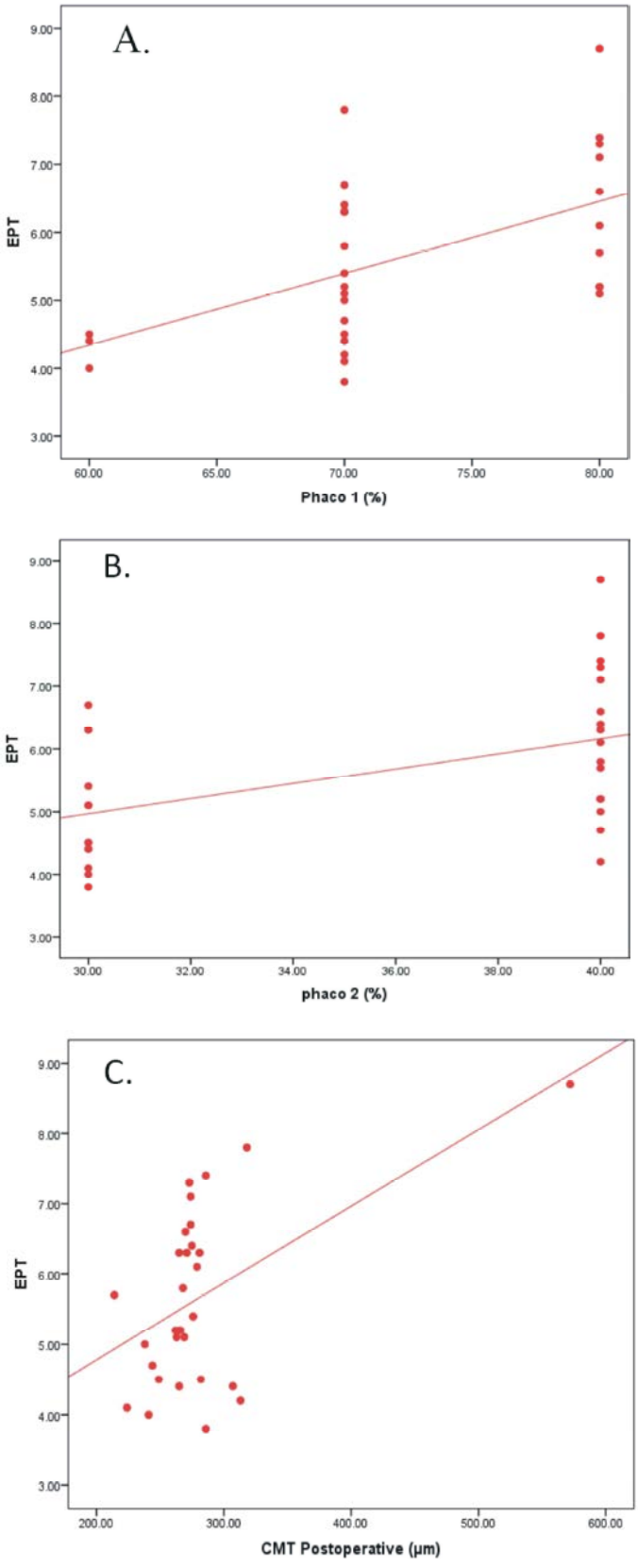

Fig. 1: Continued

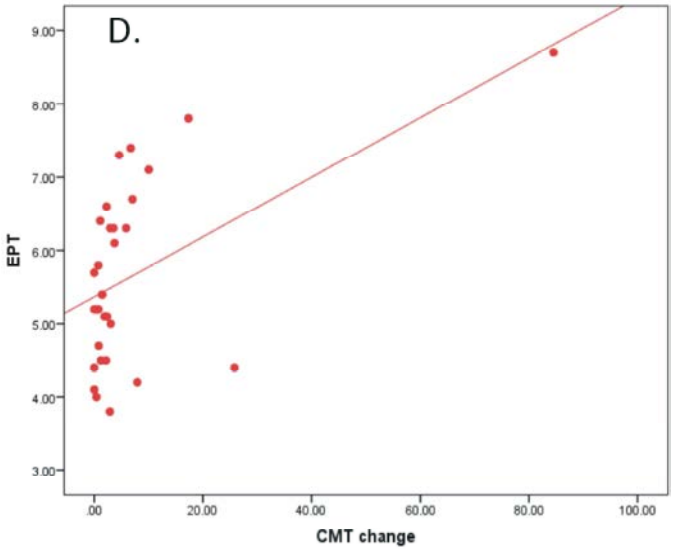

Fig. 1: Correlation of EFT with A: Phaco 1, B: Phaco 2, C: Postoperative CMT, D: CMT change (All parameters are clinically significant through Spearman correlation coefficient)

Table 1: Cataract grading distribution in the study sample (N=nuclear, PSC=posterior subcapsular, PC=posterior cortical, AC= anterior cortical)

Type of cataract (LOCS III)		No of eyes. = 30
N	N1	6 (20.0%)
	N2	24 (80.0%)
PSC	No	6 (20.0%)
	PSC1	11 (36.7%)
	PSC2	13 (43.3%)
PC	No	23 (76.7%)
	PC1	7 (23.3%)
AC	No	16 (53.3%)
	AC1	14 (46.7%)

Table 2: Comparative analysis of BCVA (Best corrected visual acuity) and CMT (Central macular thickness) with paired t test

Outcome measures	Preoperative (N=30)	1 month Postoperative (N=30)	p value
BCVA (Log MAR) (mean±SD)	0.78±0.26	0.14±0.17	0.000
CMT (µm) (mean±SD)	260.40±19.09	279.00±59.80	0.043

Table 3: Correlation of EFT (Effective phacoemulsification time) with risk parameters: Phaco 1- sculpting, Phaco 2-quadrant removal, CMT- Central macular thickness, r= Spearman correlation coefficient

	EFT	
Risk parameters	r	p value
Age (years)	0.113	0.554
Phaco 1 (%)	0.57	0.002
phaco 2 (%)	0.494	0.006
CMT Postoperative (µm)	0.365	0.048
CMT change	0.469	0.009

All patients in the study had pre-operative and 1 month post-operative data of CMT and BCVA. Table 1 shows the grading of the cataracts according to the LOCS III grading system in the study population. Nuclear cataract grade 2 was the most common type noticed in 24 out of 30 eyes (80 %).

Table 2 shows the comparison of pre-operative and post-operative data on BCVA and central macular thickness (CMT). The percentage change in CMT was noticed to be median 2.30 (IQR, 0.76–5.86). Best corrected visual acuity(LogMar) improved from 0.78 ± 0.26 to 0.14 ± 0.17 with a 60 % of improvement ($p < 0.001$). It was also found that central macular thickness (CMT) changed from 260.40 ± 19.09 µm preoperatively (Range = 214–310 µm) to 279.00 ± 59.80 µm postoperatively (Range = 214–572 µm) with a statistically significant CMT change ($p = 0.043$).

Table 3 shows the parameters related to effective phacoemulsification time during surgery and its correlation with studied risk factors. Effective phacoemulsification time was 5.64±1.24 sec (range= 3.8-8.7 sec) with phaco 1 constituting 72.33 ± 6.26 % (range, 60–80) and phaco 2 contributing 35.67 ± 5.04 % (range, 30–40). A positive correlation was inferred between CMT change and Effective Phacoemulsification Time (EPT) (p = 0.009). Fig. 1 demonstrates correlation of EFT with phaco 1, phaco 2, CMT and CMT change from preoperative state in a graphical form.

DISCUSSION

This study confirms the increase in the central macular thickness at 1 month post-operative through spectral-domain OCT following uneventful phacoemulsification in healthy eyes. These results correlate well with previous studies looking at the effect of phacoemulsification on central macular thickness. Degenring *et al*. [11] in their study on 108 eyes with OCT documented changes in macular thickness at day 1, week 1 and 4 weeks post uncomplicated phacoemulsification. Cagini *et al.* [12] followed up 62 eyes preoperatively and at 3, 6, 12, 20 and 28 weeks after surgery and observed an asymptomatic increase in retinal thickness at 3 and 6 weeks. A statistically significant increase in macular volume was reported at 12 weeks after surgery. There was no correlation between macular changes and best-corrected visual acuity (BCVA) which agrees with the findings in the present study.

A study by Von Jagow *et al*. [13] found a mild increase of foveal thickness following uncomplicated cataract surgery not impacting visual acuity in 33 eyes without previous macular pathology. The mean foveal thickness (MFT) increased after 6 weeks by 17.33± 14.81 µm, (p < 0.001). The study also looked at parameters like phaco time, energy and axial length which did not correlate with macular thickness increase in contrast to our study which establishes a positive correlation between EPT and CMT change, (p = 0.009). Similarly a study by Pardianto et al reported follow up of 27 patients who underwent uncomplicated phacoemulsification and showed a clinically significant increase in the paracentral macular area, (superior P = 0.015; temporal P=0.001; and nasal P=0.023), peripheral macular area (superior, P=0.05) and temporal macular areas, P<0.001) and overall macular volume (P=0.001). There was a significant correlation (P=0.011) noted between absolute phacoemulsification time and change in macular volume which is consistent with the results of the present study.

Hayashi *et al*. [14] compared the macular changes between 34 patients with and without diabetic retinopathy following uncomplicated phacoemulsification. The foveal thickness increased by 20.3% in the DR group and by 6.0% in the non DR group at 3 months after surgery, but thereafter decreased gradually. Foveal thickness and macular volume were significantly greater in the DR group than in the no DR group at 3 months postoperatively.

Falcao *et al*. [15] reported uncomplicated phacoemulsification induces non pathologic increases in retinal macular thickness due to the inflammatory insult of the surgery; however there was no significant changes in choroidal thickness noticed with these finding.

The mechanism of changes in the central macula following cataract surgery is still unclear. Macular thickness changes even sub clinical can now effectively be detected with the use of optical coherence tomography (OCT) and adaptive analysis software, with a peak occurring 4-6 weeks after uneventful surgery [16, 17].

Effective phacoemulsification time (EPT) is the total phacoemulsification time when utilising 100% of phaco power during surgery which can be less than the total foot-pedal time. Less EPT indicates proportionately less energy delivered to intraocular tissue therefore reducing the adverse effects of phaco power to eye [18]. Nagy *et al*. [19] concluded a less pronounced increase in the macular thickness in eyes with femtosecond-assisted cataract surgery and that the increase in thickness of the outer nuclear layer contributes to the rise in macular thickness in such cases. They described less anterior segment manipulation and a consequent lower intra ocular prostaglandins release following surgery as possible cause for this observation. Phacoemulsification, despite most commonly performed and delivering highly successful results in improving patients visual acuity is not without risks.

CONCLUSION

Cystoid macular oedema is one of the commonest cause of visual deterioration following cataract surgery. Subclinical increase in macular thickness can be detected by rapidly advancing technology of infra-red rays used in OCT scanning and is found to be reversible and does not seem to affect visual acuity. This study looked at the correlation of EPT with macular thickness and found a strong association between them following uncomplicated phacoemulsification in healthy eyes. Further studies with a larger study population and longer follow up is recommended to draw further conclusions.

Ethics Approval and Informed Consent: The study was approved as prospective audit by local institutional review board at Research Institute of Ophthalmology, Giza, Egypt and adhered to the Declaration of Helsinki.

All participants provided informed consent for participation in the study.

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