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CENTRAL CORNEAL THICKNESS AND INTRAOCULAR PRESSURE CHANGES POST- PHACOEMULSIFICATION SURGERY IN GLAUCOMA PATIENTS WITH CATARACT

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SUMMARY

Aims: To compare the changes of central corneal thickness (CCT) and intraocular pressure (IOP) post-phacoemulsification between cataract patients with and without pre-existing glaucoma.
Materials and methods: A prospective cohort study of 86 patients with visually significant cataract: 43 with pre-existing glaucoma (GC group) and 43 without pre-existing glaucoma (CO group). CCT and IOP were evaluated at baseline (pre-phacoemulsification), as well as at 2 hours, 1 day, 1 week and 6 weeks post-phacoemulsification.
Results: The GC group have significantly thinner CCT pre-operatively ($p = 0.003$). There was a steady increase of CCT with the highest peak at 1 day post-phacoemulsification, followed by a steady decline of CCT and back to baseline at 6 weeks post-phacoemulsification in both groups. The GC group demonstrated a significant difference in CCT at 2 hours (mean difference 60.2 µm, $p = 0.003$) and 1 day (mean difference 70.6 µm, $p = 0.002$) post-phacoemulsification, compared to the CO group. There was a sudden increase in IOP at 2 hours post-phacoemulsification measured by GAT and DCT in both groups. This was followed by a gradual reduction of IOP, with significant reduction at 6 weeks post-phacoemulsification in both groups. However, there was no significant difference in IOP between the two groups. IOP measured by GAT and DCT showed strong correlation ($r > 0.75$, $p < 0.001$) in both groups. There was no significant correlation between GAT-IOP and CCT changes; nor between DCT-IOP and CCT changes in both groups.
Conclusions: CCT changes post-phacoemulsification in patients with pre-existing glaucoma were similar, in spite of having thinner CCT pre-operatively. IOP measurement was not affected by CCT changes in glaucoma patients post-phacoemulsification. IOP measurement using GAT is comparable with DCT post-phacoemulsification.
Key words: central corneal thickness, intraocular pressure, phacoemulsification, glaucoma

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INTRODUCTION

Intraocular pressure (IOP) assessment is one of the key factors in the management of glaucoma. Variations in corneal properties – central corneal thickness (CCT), corneal curvature, and hydration status – may be responsible for clinically significant inaccuracies in the measurement of IOP [1-3]. Corneal hysteresis and corneal resistance may also play a role in the inaccuracy of IOP readings with Goldmann applanation tonometry (GAT) [4]. Goldmann applanation tonometry remains the gold standard for IOP measurement. GAT is affected by CCT; IOP is no longer accurate if CCT exceeds 520 µm [1].

CCT is important in the proper classification of glaucoma, whether it is primary open-angle glaucoma (POAG),

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ocular hypertension (OHT), or normotensive glaucoma (NTG). Furthermore, CCT measurement is recommended by the Ocular Hypertension Study, as it is a predictive factor for conversion of OHT to POAG. A 40 µm decrease in CCT values is associated with a 70 % higher risk of developing POAG [5,6]. Thus, measurement of CCT could assist in disease diagnosis and monitoring of progression. A thicker CCT will require higher force for applanation, leading to falsely high GAT-IOP readings. Incidence of cataract in glaucoma patients is common. This is largely due to the patient's age [7-9]. It has also been postulated that chronic instillation of topical drugs and surgical management of glaucoma may accelerate cataract formation [10-12].

Phacoemulsification is the most common surgical technique for cataract extraction surgery. Common post-phacoemulsification complications include transient elevation of IOP, corneal edema, wound leakage, loose sutures, and punctate epitheliopathy [13]. In certain cases, elevated IOP necessitates pressure-lowering medication. Direct or indirect injury to the endothelial cells may cause transient corneal edema postoperatively [14]. Transient corneal edema may result in inaccurate GAT-IOP readings. Underestimation of IOP may cause under-detection of transient IOP elevation, which can have detrimental effects in glaucoma patients. Untreated sudden spikes in IOP may lead to further mechanical damage to the nerve fiber layer in already compromised eyes [15]. However, overtreatment may lead to ocular hypotony and cause intra-axonal alteration of morphology with disruption of axoplasmic transport to the optic nerve head, accelerating further nerve fiber layer damage [16]. Accurate IOP measurement is important in controlling IOP postoperatively in glaucoma patients. The purpose of this study was to compare mean CCT and IOP pre- and post-phacoemulsification in cataract patients with and without pre-existing glaucoma. In addition, the correlations between CCT and IOP pre- and post-phacoemulsification were also studied.

MATERIALS AND METHODS

This non-randomized prospective cohort study involved 86 patients with visually significant cataract: 43 with pre-existing glaucoma (GC group) and 43 without pre-existing glaucoma (CO group). Patients were recruited from the eye clinics of Raja Permaisuri Bainun Hospital (HRPB), Perak, Malaysia, and Hospital Universiti Sains Malaysia (HUSM), Kelantan, Malaysia. This study received ethical approval from the Human Research Ethics Committee, School of Medical Sciences, Universiti Sains Malaysia and the Ethical and Medical Research Committee of the Ministry of Health, Malaysia.

Patients with pre-existing corneal pathology, high refractive aberrations, a history of refractive surgery, or who were indicated for glaucoma filtering surgery, were excluded. In this study, cataract patients without pre-existing glaucoma (CO group) were regarded as controls. In addition, those who were selected pre-operatively were excluded if they developed posterior capsular rent or zonulodialysis intra-operatively.

Written informed consent was taken for both the GC group and CO group for participation in the study and for the phacoemulsification surgery. A pre-operative assessment was conducted one week prior to phacoemulsification surgery. The eligibility of the patients was determined based on slit-lamp examination, gonioscopy, and evaluation of the posterior segment (if possible). CCT measurement was obtained using anterior segment optical coherence tomography (OCT) (Carl Zeiss Meditec Inc., Dublin, CA, USA) by a trained technician. After the CCT was measured, we proceeded with IOP measurement by the primary investigator (NHK), using GAT (GAT-IOP) and dynamic contour tonometry (DCT-IOP) (Ziemer Ophthalmic Systems, Port, Switzerland) in a sitting position between 9:00 and 12:00 in the morning.

Phacoemulsification was conducted under local (topical) anesthesia, and the posterior chamber intraocular lens was implanted. Phacoemulsification was performed by the same team of experienced surgeons at both centers, which involved 2 experienced surgeons in HRPB, and 2 experienced surgeons in HUSM. Postoperatively, patients were started on Prednisolone acetate 1 % drops 2-hourly and Ciprofloxacin drops 6-hourly for 1 week, tapering until 6 weeks. CCT, GAT-IOP, and DCT-IOP were measured at 2 hours, 1 day, 1 week, and 6 weeks post-phacoemulsification. Three readings of IOP were taken, using GAT in the sitting position, and the mean of the three readings was recorded as the IOP for subsequent analysis. DCT-IOP measurement was based on a quality index (Q score) of at least 3 or better.

Statistical analysis was conducted using SPSS version 26 (International Business Machines Corporation, New York, USA). CCT, GAT-IOP, and DCT-IOP changes were analyzed using repeated measures analysis of variance. Pearson's correlation was used to determine the correlation between CCT and IOP changes and between GAT and DCT. A Bland–Altman plot was used to compare the two IOP measurements. A paired t-test was used to compare the mean IOP between groups.

RESULTS

A total of 86 patients (43 GC and 43 CO) were enrolled in this study. The cataract patients' group with pre-existing glaucoma were older (Table 1). Sixteen POAG, 8 NTG, 2 pseudoexfoliation glaucoma (PXG), 13 primary angle closure glaucoma (PACG), and 4 secondary glaucoma patients were included in the GC group (Table 2). Mean CCT pre-phacoemulsification was 517.0 µm and 540.0 µm in GC and CO groups respectively. There was no significant difference in mean baseline IOP between both groups (Table 3).

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Table 1: Comparison of demographic data between GC and CO groups

Demographic characteristic	GC group (N = 43)	CO group (N = 43)	p-value
Mean age, mean ±SD	69.5 ±7.4	68.0 ±7.8	0.380[+]
Gender, n (%)			
Male	19 (41.2)	21 (48.8)	0.517[++]
Female	24 (55.8)	22 (51.2)	
Ethnicity, n (%)			
Malay	14 (32.6)	14 (32.5)	0.592[+++]
Chinese	24 (55.8)	22 (51.2)	
Indian	4 (9.3)	7 (16.3)	
Others	1 (2.3)	0 (0)	
Systemic disease, n (%)			
Diabetes mellitus	20 (46.5)	24 (55.8)	0.388[++]
Hypertension	30 (69.8)	30 (69.8)	> 0.950[++]
Chronic kidney disease	1 (2.3)	1 (2.3)	> 0.950[+++]
Ischemic heart disease	11 (25.6)	6 (14.0)	0.559[++]
Hyperlipidemia	8 (18.6)	6 (14.0)	0.176[++]
Other diseases	5 (11.6)	3 (7.0)	0.713[+++]

[+] p < 0.05 is considered statistically significant based on independent t-test,
[++] p < 0.05 is considered statistically significant based on Pearson chi-square test,
[+++] p < 0.05 is considered statistically significant based on Fisher's exact test,
SD – Standard deviation, GC – glaucoma patient with cataract, CO – cataract patient only

Table 2: Glaucoma characteristic data in GC group

Glaucoma characteristics	N (%)
Type of glaucoma	
POAG	16 (37.2)
NTG	8 (18.6)
PEXG	2 (4.7)
PACG	13 (30.2)
Secondary	4 (9.3)
Severity of glaucoma[#]	
Early	6 (14.0)
Moderate	8 (18.6)
Advanced	11 (25.6)
Severe	3 (6.9)
Unavailable	15 (34.9)
Number of medications	
Monotherapy	17 (39.5)
Dual therapy	23 (53.5)
Triple therapy	2 (4.7)
More than 3	1 (2.3)
Type of medication	
Prostaglandin analogue	28 (65.1)
β-blocker	28 (65.1)
Carbonic anhydrase inhibitor	10 (23.3)
α-agonist	7 (16.3)
Others	1 (2.3)

[#] Severity of glaucoma based on Glaucoma Staging System (GSS) by Mills et al (2006).
GC – glaucoma patient with cataract, POAG – Primary open angle glaucoma, NTG – Normotensive glaucoma, PEXG – Pseudoexfoliation glaucoma, PACG – Primary angle closure glaucoma

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There was a sudden increase in CCT after phacoemulsification, which peaked at Day 1 (24 hours). However, there was a progressive reduction of CCT subsequently and it returned to preoperative thickness at 6 weeks post-phacoemulsification in both groups. Multiple paired t-tests with Bonferonni correction showed a significant difference in mean CCT between baselines (preoperative), and at 2 hours and 24 hours post-phacoemulsification in both groups. There was a significant change in mean CCT between GC and CO groups (Graph 1). There was a 26.1 % (134.7 ±95.3 µm) increase in CCT at 1 day post-phacoemulsification in the GC group, which was lower than the CO group 33.7 % (182.3 ±110.3 µm) (Table 4).

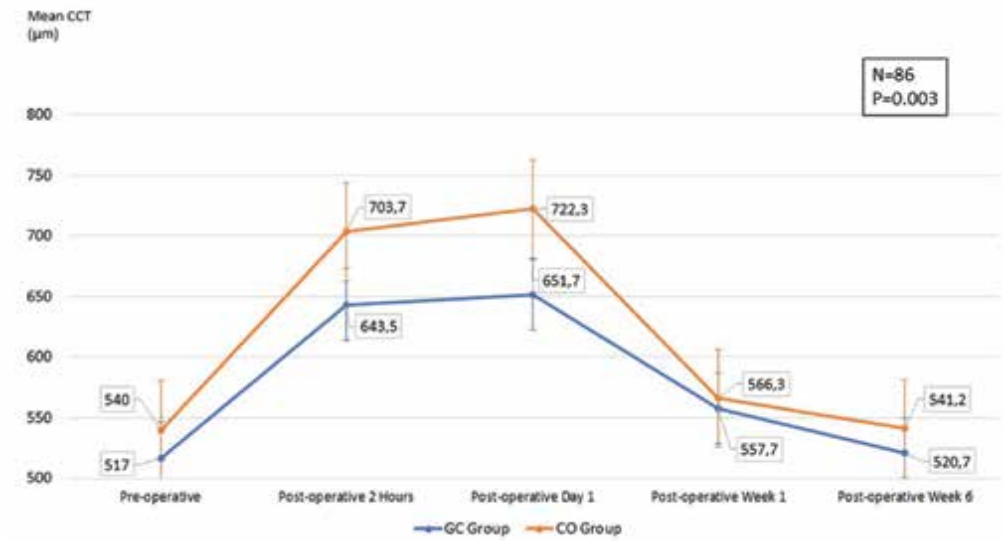
The pre-phacoemulsification mean IOP was lower in the GC group by 0.3 mmHg compared to the CO group. Elevated IOP measured by GAT- IOP was observed after phacoemulsification and reached its peak at 2 hours post-phacoemulsification in both groups (Graph 2). Similar to CCT changes, GAT-IOP showed a progressive reduction over time. In fact, the GAT-IOP reduced even below the baseline at 6 weeks post- phacoemulsification in both groups. There was significant GAT-IOP reduction by 3.4 mmHg between 2 hours and 1 week post-phacoemulsification in the GC group. A significant reduction of 2.1 mmHg between pre-phacoemulsification and 1 week post- phacoemulsification was observed in the CO group (Table 5). In general, there was a higher mean of GAT-IOP in the GC group, but without a significant difference between the groups.

There was steady elevation of DCT-IOP post--phacoemulsification, that reached its peak at 2 hours

Table 3: Comparison of pre-operative data between GC and CO groups

Pre-operative data	GC group	CO group	p-value
	(N = 43)	(N = 43)	
Visual acuity in LogMar, mean ±SD	0.8 ±0.6	0.7 ±0.4	0.385#
Baseline IOP, mean ±SD	15.6 ±4.0	15.9 ±2.3	0.658##
Cataract grading, mean ±SD			
Nucleus colour	2.4 ±0.8	2.3 ±0.7	0.570#
Nucleus opalescence	2.4 ±0.8	2.4 ±0.7	0.377#
Cortical cataract	0.2 ±0.7	0.3 ±0.8	0.356#
Posterior subcapsular cataract	0.8 ±1.2	1.6 ±1.2	**0.002**#
Vertical CDR, mean ±SD	0.7 ±0.2	0.4 ±0.1	**< 0.001**#

 # p < 0.05 is considered statistically significant based on Mann-Whitney test,
p < 0.05 is considered statistically significant based on independence t-test.
GC – glaucoma patient with cataract, CO – cataract patient only, IOP – Intraocular pressure, CDR – cup disc ratio



Graph 1. Mean inter-visit CCT between GC and CO groups based on time

P < 0.05 is considered statistically significant based on RM ANOVA,
CCT – Central corneal thickness, GC – glaucoma patient with cataract, CO – cataract patient only, RM ANOVA – repeated measure analysis of variance

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in both groups (Graph 3). Similar to GAT-IOP changes, DCT-IOP showed progressive reduction over time. There was significant reduction of 3.8 mmHg between 2 hours and 1 week post-phacoemulsification in the GC group. Further IOP reduction was observed, with a significant reduction of 5.0 mmHg between 2 hours and 6 weeks post-phacoemulsification in the GC group. A significant reduction of 2.0 mmHg between pre-phacoemulsification and 1 week post-phacoemulsification was observed in the CO group. There was a higher reduction of 2.9 mmHg between pre-phacoemulsification and 6 weeks post-phacoemulsification (Table 6). However, there was no significant difference of mean DCT-IOP between the groups.

There was a strong correlation between mean GAT-IOP and DCT-IOP in both groups pre- and post-phacoemulsification (Table 7). However, there was no correlation between CCT changes, GAT changes and DCT changes (Table 8).

It is worth mentioning that, throughout this study, neither GC group nor CO group needed any systemic IOP-lowering agents, in view of all our patients showing an acceptable range of IOP readings. Postoperatively, patients continued their previous antiglaucoma medications.

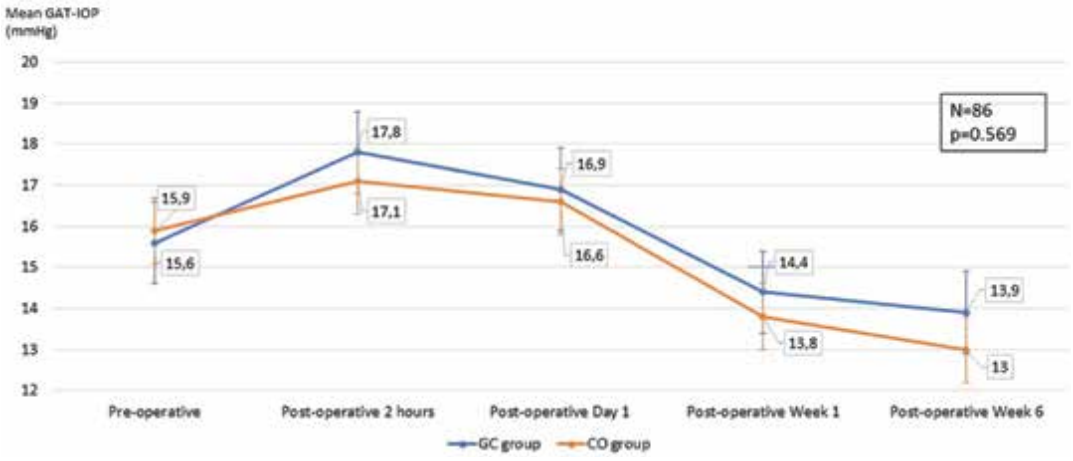
Table 4: Mean CCT difference between pre-op and post-op visits in GC and CO groups

Time Pairing[#]	GC group		CO group	
	Mean CCT difference (95% CI)	p-value	Mean CCT difference (95% CI)	p-value[##]
CCT 1- CCT 2	-126.5 (-162.8, -90.2)	**< 0.001**	-163.7 (-208.4, -119.0)	**< 0.001**
CCT 1- CCT 3	-134.8 (-177.9, -91.7)	**< 0.001**	-182.3 (-232.2, -132.5)	**< 0.001**
CCT 1- CCT 4	-40.7 (-68.5, -12.9)	**0.001**	-26.3 (-49.8, -2.8)	0.019
CCT 1- CCT 5	-3.7 (-10.5,3.0)	> 0.950	-1.2 (-19.8, 17.4)	> 0.950
CCT 2 -CCT 3	-8.3 (-29.5, 12.9)	> 0.950	-18.6 (-38.9, 1.7)	0.095
CCT 2 -CCT 4	85.8 (49.7, 121.9)	**< 0.001**	137.4 (94.2, 180.7)	**< 0.001**
CCT 2 -CCT 5	122.8 (87.5, 158.1)	**< 0.001**	162.6 (117.6, 207.6)	**< 0.001**
CCT 3 -CCT 4	94.1 (54.8, 133.4)	**< 0.001**	156.0 (110.0, 202.1)	**< 0.001**
CCT 3 -CCT 5	131.0 (89.4, 172.7)	**< 0.001**	181.2 (131.4, 231.0)	**< 0.001**
CCT 4 -CCT 5	37.0 (10.7, 63.2)	**0.001**	25.1 (7.7, 42.6)	**0.001**

[#]CCT 1 is baseline CCT, CCT 2 is CCT at 2 hours post-op, CCT 3 is CCT at Day 1 post-op, CCT 4 is CCT at Week 1 post-op and CCT 5 is CCT at Week 6 post-op,

[##]p < 0.005 is considered statistically significant based on RM ANOVA within group analysis followed by pairwise comparison with 95% confidence interval adjustment by Bonferroni correction,

GC – glaucoma patient with cataract, CO – cataract patient only, CCT – central corneal thickness, CI – Confidence interval, RM ANOVA – Repeated measure analysis of variance



Graph 2. Mean inter-visit GAT-IOP between GC and CO groups based on time

P < 0.05 is considered statistically significant based on RM ANOVA,

GAT-IOP – Goldmann applanation tonometry-intraocular pressure, GC – glaucoma patient with cataract, CO – cataract patient only, RM ANOVA – repeated measure analysis of variance

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Table 5: Mean GAT-IOP difference between pre-op and post-op visits in GC and CO groups

Time Pairing[#]	GC group		CO group	
	Mean GAT-IOP difference (95% CI)	p-value	Mean GAT-IOP difference (95% CI)	p-value[##]
GAT 1-GAT 2	-2.3 (-4.7, 0.1)	0.078	-1.2 (-3.0, 0.5)	0.464
GAT 1-GAT 3	-1.4 (-4.5, 1.7)	>0.950	-0.7(-2.1, 0.8)	> 0.950
GAT 1-GAT 4	1.1 (-0.7, 3.0)	0.801	2.1 (0.9, 3.4)	**< 0.001**
GAT 1-GAT 5	1.7 (0.0, 3.4)	0.047	2.9 (1.7, 4.0)	**< 0.001**
GAT 2-GAT 3	0.9 (-1.4, 3.2)	>0.950	0.5 (-0.3, 1.4)	0.758
GAT 2-GAT 4	3.4 (1.2, 5.7)	**0.001**	3.3 (1.8, 4.9)	**< 0.001**
GAT 2-GAT 5	4.0 (1.7, 6.3)	**<0.001**	4.1 (2.7, 5.4)	**< 0.001**
GAT 3-GAT 4	2.5 (-0.2, 5.2)	0.089	2.8 (1.4, 4.2)	**< 0.001**
GAT 3-GAT 5	3.1 (0.2, 6.0)	0.027	3.5 (2.3, 4.8)	**< 0.001**
GAT 4-GAT 5	0.6 (-0.9, 2.0)	> 0.950	0.7 (-0.1, 1.6)	0.141

[#] GAT 1 is baseline GAT-IOP, GAT 2 is GAT-IOP at 2-hour post-op, GAT 3 is GAT-IOP at Day 1 post-op, GAT 4 is GAT-IOP at Week 1 post-op and GAT 5 is GAT-IOP at Week 6 post-op,
[##] p<0.005 is considered statistically significant based on RM ANOVA within group analysis followed by pairwise comparison with 95% confidence interval adjustment by Bonferroni correction,
GC – glaucoma patient with cataract, CO – cataract patient only, GAT – Goldmann applanation tonometry, IOP – Intraocular pressure, CI – Confidence interval, RM ANOVA – Repeated measure analysis of variance

Table 6: Mean DCT-IOP difference between pre-op and post-op visits in GC and CO groups

Time Pairing[#]	GC group		CO group	
	Mean DCT-IOP difference (95% CI)	p-value[##]	Mean DCT-IOP difference (95% CI)	p-value[##]
DCT 1- DCT 2	-2.5 (-5.6, 0.5)	0.176	-1.7 (-3.5, -0.1)	0.070
DCT 1- DCT 3	-1.4 (-4.8, 1.9)	> 0.950	-1.0 (-2.5, 0.6)	0.850
DCT 1- DCT 4	1.3 (-1.2, 3.8)	> 0.950	2.0 (0.6, 3.3)	**0.001**
DCT 1- DCT 5	2.5 (0.4, 4.6)	0.012	2.9 (1.7, 4.2)	**< 0.001**
DCT 2 -DCT 3	1.1 (-1.2, 3.4)	> 0.950	0.8 (-0.4, 1.9)	0.592
DCT 2 -DCT 4	3.8 (1.4, 6.3)	**< 0.001**	3.7 (2.0, 5.4)	**< 0.001**
DCT 2 -DCT 5	5.0 (2.4, 7.6)	**< 0.001**	4.6 (3.0, 6.3)	**< 0.001**
DCT 3 -DCT 4	2.7 (0.1, 5.3)	0.033	2.9 (1.3, 4.6)	**< 0.001**
DCT 3 -DCT 5	3.9 (1.0, 6.8)	**0.002**	3.9 (2.3, 5.4)	**< 0.001**
DCT 4 -DCT 5	1.2 (-0.4, 2.8)	0.347	1.0 (0.2, 1.8)	0.011

[#]DCT 1 is baseline DCT-IOP, DCT 2 is DCT-IOP at 2-hour post-op, DCT 3 is DCT-IOP at Day 1 post-op, DCT 4 is DCT-IOP at Week 1 post-op and DCT 5 is DCT-IOP at Week 6 post-op. CI is Confidence interval,
[##]p<0.005 is considered statistically significant based on RM ANOVA within group analysis followed by pairwise comparison with 95% confidence interval adjustment by Bonferroni correction,
GC – glaucoma patient with cataract, CO – cataract patient only, DCT – Dynamic contour tonometry, IOP – Intraocular pressure, RM ANOVA – Repeated measure analysis of variance

Table 7: Correlation of GAT-IOP and DCT-IOP pre- and post-phacoemulsification in GC and CO groups

Time pairing	GC group	p-value[#]	CO group	p-value[#]
	Pearson correlation		Pearson correlation	
Pre-op	0.945	< 0.001	0.938	< 0.001
Post-op 2 hours	0.925	< 0.001	0.881	< 0.001
Post-op day 1	0.927	< 0.001	0.862	< 0.001
Post-op week 1	0.826	< 0.001	0.943	< 0.001
Post-op week 6	0.815	< 0.001	0.925	< 0.001

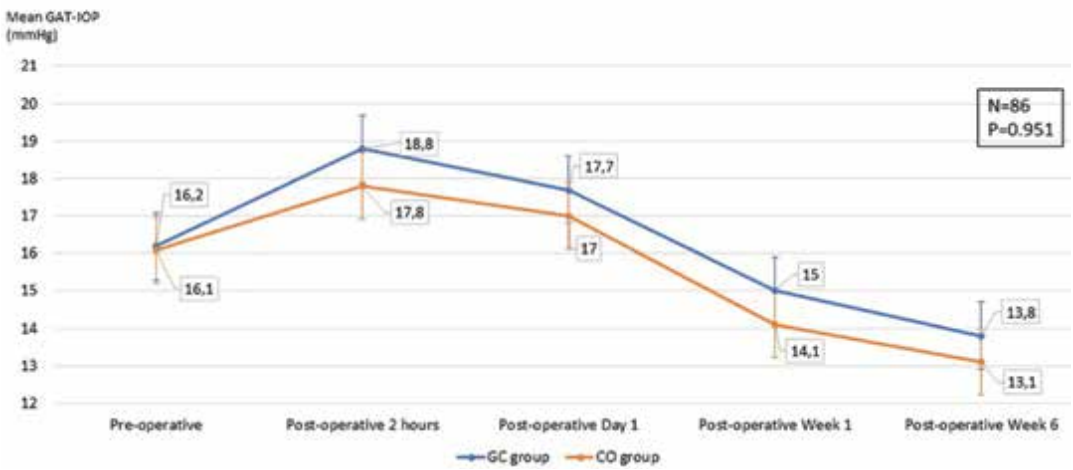
[#]p < 0.01 is considered statistically significant based on Pearson's correlation coefficient,
GAT – Goldmann applanation tonometry, IOP – Intraocular pressure, DCT – Dynamic contour tonometry, GC – glaucoma patient with cataract, CO – cataract patient only

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Table 8: Correlation of CCT difference with IOP difference pre- and post- phacoemulsification in CO group

Pairing of CCT and IOP difference	Correlation coefficient	p value*
GAT		
CCT (pre-op -2H) & IOP (pre-op -2H)	0.159	0.309
CCT (pre-op -D1) & IOP (pre-op -D1)	0.295	0.055
CCT (pre-op -W1) & IOP (pre-op -W1)	0.171	0.273
CCT (pre-op -W6) & IOP (pre-op -W6)	0.126	0.422
DCT		
CCT (pre-op -2H) & IOP (pre-op -2H)	0.286	0.063
CCT (pre-op -D1) & IOP (pre-op -D1)	0.266	0.085
CCT (pre-op -W1) & IOP (pre-op -W1)	0.267	0.083
CCT (pre-op -W6) & IOP (pre-op -W6)	0.264	0.087

**p < 0.01 is considered statistically significant based on Spearman's rho correlation coefficient,*
2H is 2-hour post-op, D1 is Day 1 post-op, W1 is Week 1 post-op, W6 is Week 6 post-op,
CCT – Central corneal thickness, IOP – Intraocular pressure, GAT – 015 Goldmann applanation tonometry, DCT – Dynamic contour tonometry



Graph 3. Mean inter-visit DCT-IOP between GC and CO group based on time

P < 0.05 is considered statistically significant based on RM ANOVA,
DCT-IOP – Dynamic contour tonometry-intraocular pressure, GC – glaucoma patient with cataract,
CO – cataract patient only, RM ANOVA – repeated measure analysis of variance

DISCUSSION

Mean CCT pre-phacoemulsification was 23.0 µm, thinner in cataract patients with pre-existing glaucoma, compared to those without pre-existing glaucoma in the present study. It has been reported that glaucoma patients have thinner CCT compared to non-glaucoma patients [17]. Thinner CCT was associated with more severe glaucoma [17,18]. In this study, the majority of eyes had moderate to severe glaucoma. In addition, the glaucoma patients were older than the non-glaucoma patients. There was a significant association between age and CCT [19-21].

Cataract patients with pre-existing glaucoma tend to have a significantly thinner CCT. However, the higher prevalence of diabetes mellitus among the cataract patients without pre-existing glaucoma may have contributed to their thicker CCT. CCT was 6.5 µm thicker in diabetes mellitus patients compared to non-diabetic patients [22].

Phacoemulsification causes postoperative corneal edema, leading to increased CCT. In spite of thinner CCT in cataract patients with pre-existing glaucoma, the changes in CCT post-phacoemulsification were similar in cataract patients with and without pre-existing glaucoma. As expected, there was a sudden increase in CCT at 2 hours and it peaked at 24 hours post-phacoemulsification. Similar findings were reported from previous studies by Tao A et al., Bolz M et al., Salvi SM et al., Herr A et al., and Fuest M et al., which reported significant increased CCT after 1 day post-phacoemulsification [23-27].

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This was followed by a steady reduction in CCT over time, which returned to pre-phacoemulsification level at 6 weeks post-surgery. In our study, a longer duration for CCT to return to its pre-phacoemulsification level was observed. While most previous studies reported CCT returned to baseline after 1 week [23-25], a study was done by Noronha D et al., where the CCT returned to baseline at 1 month post-surgery [28]. Cetinkaya et al. studied post-phacoemulsification in ocular hypertensive patients and reported a longer time to reach baseline CCT, which was 3 months [29]. The longer duration of the CCT to return to baseline in our study may have been due to a larger quantum of CCT increment at 2 hours post-phacoemulsification as compared to other studies. However, the Scheimpflug camera system was used in those previous studies, which may not be comparable to our technique of CCT measurement using the anterior segment OCT [30]. In addition, the phacoemulsification was conducted by a panel of surgeons at a different hospital. Those surgeons may have their own techniques, preferences, phacoemulsification settings and levels of expertise [31-35]. Ideally, a single surgeon from each hospital should be responsible for conducting the surgeries. Moreover, the CCT may also be affected by the type of glaucoma. In this study, although the majority were POAG patients, NTG and PXG patients were also included. NTG and PXG patients have been reported to have thinner CCT compared to POAG and to the normal population [36,37]. In addition, a lower endothelial cell count has been observed in glaucoma patients [38,39]. There was a significantly longer duration of cataract surgery overall among cataract patients with pre-existing glaucoma in the present study. This is perhaps due to the greater instrumentation and manipulation needed in patients with pre-existing glaucoma. The effective phacoemulsification time was also longer in these patients. Unfortunately, the endothelial cell count was not included in the present study. Inclusion of diabetes mellitus patients in both groups may cause a more significant increase of mean CCT [40].

CCT is known to affect the IOP measurement using GAT [1]. Thinner CCT is associated with a falsely low IOP [41]. In this study, cataract patients with pre-existing glaucoma recorded lower IOP pre-phacoemulsification compared to those without pre-existing glaucoma. This is not surprising, as only glaucoma patients with well-controlled IOP were included in the present study. In addition, glaucoma patients with systemic comorbidities, especially systemic hypertension, were also included. However, as part of preoperative evaluation, their systemic blood pressure had to be controlled by systemic antihypertensive drugs, which can further lower the IOP [42].

In the present study, there were similar changes in IOP measured by GAT and DCT post-phacoemulsification. There was an acute spike of IOP at 2 hours post-phacoemulsification, followed by a steady decline in IOP. A higher acute increase in IOP was observed in cataract patients with pre-existing glaucoma post-phacoemulsification. This was expected, as these patients required relatively more manipulations, leading to more inflammation and a higher volume of viscoelastic usage, which contributes to the spike in pressure. However, once reabsorption of viscoelastic was complete, the IOP was reduced. The mean IOP was lower at 6 weeks post-phacoemulsification compared to pre-phacoemulsification. Phacoemulsification is known to cause transient IOP reduction, due to the anatomical changes, as reported by Poley et al., Shingleton et al., and Kim et al. [43-45].

However, there was no significant difference in mean IOP (measured by GAT and DCT) between cataract patients with and without pre-existing glaucoma. In addition, although the changes in CCT were similar to IOP changes post-phacoemulsification, there was no significant correlation between CCT and IOP. Surprisingly, there was also no significant difference in mean IOP measured by GAT and DCT. This may have been due to the relatively small sample size, or to the significantly thinner CCT in the GC group compared to the CO group, which resulted in underestimation of GAT-IOP compared to true IOP. After surgery, DCT-IOP revealed significantly higher IOP at 2 hours and 1 day post-phacoemulsification in both groups. As GAT is known to deviate due to changes in corneal biomechanical property, this showed that increased CCT post-phacoemulsification as a result of corneal edema caused underestimation of GAT-IOP in the acute post-op period (especially at 2 hours and 1 day post-phacoemulsification), and this significant difference was larger in the GC group compared to the CO group.

In this study, we measured the IOP using two instruments, GAT and DCT, to ascertain the difference when the cornea was edematous. However, we did not measure the cornea hysteresis and cornea resistance factor, which are important factors in assessing the corneal biomechanical property.

Both groups showed a significant IOP reduction at 6 weeks post-phacoemulsification. This proved the benefit of cataract surgery in controlling the IOP in patients with simultaneous glaucoma and cataract pathologies. We also suggested that IOP monitoring in the early postoperative phase is feasible without the concurrent CCT, as the measurement changes are not crucial and pre-measurement thickness will be regained after 6 weeks.

CONCLUSION

There was a significant difference in mean CCT between the GC and CO groups over time. There was a significant increase in CCT in both groups, peaking at 1 day post-phacoemulsification, although patients with pre-existing glaucoma had thinner CCT pre-operatively. There was no correlation between CCT and IOP changes post-phacoemulsification in either group. IOP measurement was not affected by CCT changes in glaucoma patients post-phacoemulsification.

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