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Study on Correlation of Glycosylated Haemoglobin (Hba1c) Levels with The Refractive Status and Ocular Anterior Segment Structures In Type 2 Diabetes Mellitus Patients

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Abstract

Introduction: Type 2 diabetes mellitus (T2DM) is a prevalent chronic condition associated with systemic and ocular complications. This study aimed to evaluate the correlation between glycosylated haemoglobin (HbA1c) levels and anterior segment parameters—visual acuity (VA), anterior chamber depth (ACD), and crystalline lens thickness (CLT)—in T2DM patients.

Materials and Methods: A study was conducted over one year, enrolling 85 T2DM patients aged above 45 years. HbA1c levels were categorized into four groups. VA was recorded using Snellen’s chart, and ACD and CLT were measured using an A-scan biometer.

Results: There was a statistically significant negative correlation between HbA1c and both VA and ACDA significant positive correlation was observed between HbA1c and CLT. These correlations strengthened progressively across the HbA1c groups.

Conclusion: Poor glycaemic control in T2DM patients is significantly associated with reduced visual acuity, decreased anterior chamber depth, and increased lens thickness. These findings emphasize the importance of regular ocular evaluations and strict glycaemic control to prevent vision-related complications in diabetic individuals.

Keywords: T2 DM, glycosylated haemoglobin, CLT, visual acuity, ACD, crystalline lens, HbA1c, anterior chamber

Introduction

Diabetes mellitus, the most common chronic metabolic disorder, accounts for approximately 90–95% of diabetes cases worldwide. It results from insufficient insulin secretion or resistance to its action, leading to persistent hyperglycaemia and glycosuria, along with multiple metabolic complications. T2DM affects various organ systems, notably the eyes, heart, kidneys, and nerves. Ocular involvement can impair visual quality and refractive stability, often necessitating frequent changes in vision correction.[1]

Measurement of glycosylated haemoglobin (HbA1c) offers an assessment of the average blood glucose concentration over the prior two to three months. The cornea, anterior chamber, iris, and crystalline lens constitute the anterior segment of the eye and their susceptibility to hyperglycemia induced changes were increasingly being studied in past. The earlier study evaluated HbA1c levels and their impact on important anterior segment parameters, such as anterior chamber depth (ACD), crystalline lens thickness (CLT), and refractive status. Understanding these associations was essential for optimizing vision correction in diabetic patients.[2]

Changes in anterior chamber depth (ACD) can influence the eye's total refractive power, thereby affecting both the natural refractive status and the precision of intraocular lens (IOL) power estimation during cataract surgery. A reduction in ACD, as seen in some individuals with diabetes, may contribute to increased refractive errors.[2] Accurate measurement of anterior chamber depth is crucial for understanding ocular status, particularly in DM patients, where structural changes in the eye may occur. Several methods such as Scheimpflug Photography, Ultrasound biometry, optical coherence tomography (AS-OCT), Pentacam (Rotational Scheimpflug Camera), Orbscan (Placido-Disc Corneal Topography), Auto refraction and Keratometry-Based Techniques, and Anterior Segment Ultrasound (AS- US), have been developed over time to measure ACD, each with its own advantages and limitations.[3,4,5]

Crystalline lens is a transparent biconvex structure situated behind the iris and the osmotic gradient due to high blood glucose levels can lead to lens fibers swelling, resulting in lens thickening. Elevated glucose levels also increases intracellular sorbitol, an osmotically active polyol, which further drives water influx into lens cells, causing lens swelling and affecting lens transparency. Initial stages of hyperglycaemia commonly causes, a myopic shift; conversely, as blood glucose levels return to normal, the lens thickness often decreases, causing a hyperopic shift.[6,7]

Elevated HbA1c levels have been linked to increased risks of both microvascular and macrovascular complications, including those affecting ocular structures. Although diabetic retinopathy remains a primary cause of visual impairment, the anterior segment's role in refractive stability is becoming clearer. Understanding the influence of HbA1c on ACD, CLT, and refractive status could provide clinicians with valuable insights. Improved glycaemic control may lead to greater stability in these parameters, potentially reducing the frequency of refractive fluctuations and enhancing the quality of life for diabetic patients.[8]

By studying HbA1c levels in correlation to the structural changes in anterior segment of eye, present research aims to establish whether better glycaemic control could mitigate visual disturbances and refractive variability, offering new insights into managing ocular health in diabetic patients.

Materials And Methods

This study was carried out over one year in the Ophthalmology Department. Ethical approval was obtained from the Institutional Ethics Committee (Ref No: KDMCHRC/IEC/2023/34). A total of 85 patients were enrolled

Inclusion criteria

All individuals aged above 45 years, of either sex, who had a confirmed diagnosis of Type 2 diabetes mellitus.

Exclusion criteria

- Individuals who declined to participate or did not provide written consent were excluded

- Participants with visual impairment due to non-diabetic causes such as congenital anomalies, amblyopia, or strabismus
- Subjects with existing ocular conditions—including corneal, lenticular, or retinal pathologies—or those with systemic illnesses like hypertension
- Patients diagnosed with glaucoma or with a known family history of glaucoma.

Study Methodology

The blood samples were collected at random time from medial cubital vein, as preferred site, using 5 ml syringe. Blood was taken in EDTA vial and samples were sent for random blood sugar and HbA1c levels measurements using colorimetric and turbidometric immune-inhibition method in Roche 400 machine. Random blood sugar levels >200mg/dl and HbA1c values more than 6.5% were suggestive of diabetes mellitus. For this study the HbA1c values were grouped as

- Study group I: 6.5 to 7.0%
- Study group II: 7.0 to 8.0%
- Study group III: 8.0 to 10%
- Study group IV: >10%

- Visual acuity was assessed using the Snellen's chart positioned at a standard distance of 6 meters (20 feet), and the readings were subsequently converted into decimal equivalents for statistical evaluation.
- Anterior chamber depth was evaluated using the Sonomed Model 300A+ Amplitude (A- scan) device, following the application of topical anesthesia with 0.5% proparacaine. The device generated visual spikes on a monitor, with the pattern and spacing of these spikes corresponding to intraocular structures and the distances between them. Both anterior chamber depth and crystalline lens thickness were documented for the purposes of this study.

Statistical analysis

Data analysis was performed using MS Excel, in SPSS version 25. Descriptive statistics included percentages for categorical variables and mean ± standard deviation for continuous variables. Categorical comparisons were made using the Chi-square test or Fisher's exact test. For continuous variables, the Student's t-test or Mann-Whitney U test was used for unpaired data, while the paired t-test or Wilcoxon signed- rank test was applied to paired data. Repeated Measures ANOVA was used for multi group comparisons, followed by Dunn's post hoc test. A p-value < 0.05 was considered statistically significant.

Results

This study totally enrolled 85 patients (52 males and 33 females) and majority of patients (42%) were in the age range of 45-65 years. Among total patients, study group I (HbA1c levels 6.5-7.0%) patients had 7.05% patients, and a mean value of 6.72 ± 0.18%. The study group II (HbA1c levels 7.0-8.0%), comprises 16.47% with mean of 7.34 ± 0.31%. The largest proportion of study group III patients, 42.35%, fell within the HbA1c range of 8.0% to 10.0%, with a mean of 8.80 ± 0.54%. The remaining 34.11% patients of study group IV (HbA1c values >10.0%) had a mean HbA1c 11.00 ± 0.56%. This distribution reflected the varying glycaemic control among study patients, which was essential for assessing its correlation with anterior chamber depth, crystalline lens thickness, and refractive status in diabetes mellitus patients.

Our study analysed the correlation of HbA1c levels with mean values of visualacuity, anterior chamber depth and crystalline lens thickness across different glycaemic study groups. In study group I patients a negative correlation was observed for both visual acuity (r = -0.42, p = 0.003) and anterior chamber depth (r = -0.35, p =

0.012), whereas crystalline lens thickness showed a positive correlation (r = 0.39, p = 0.007). As HbA1c increased to the 7.0%-8.0% range in study group II the negative correlation with visual acuity (r = -0.51, p < 0.001) and anterior chamber depth (r = -0.48, p< 0.001) became stronger, while the correlation with crystalline lens thickness (r = 0.53, p < 0.001) also increased.

Study group III patients exhibited a further decline in visual acuity (r = -0.60, p < 0.001) and anterior chamber depth (r = -0.55, p < 0.001), while lens thickness showed an increasing trend (r = 0.58, p < 0.001). In study group IV individuals with poorly controlled diabetes and HbA1c levels exceeding 10%, the strongest correlations were noted, with visual acuity (r = - 0.72, p < 0.001) and anterior chamber depth (r = -0.65, p < 0.001) showing the highest negative association, while crystalline lens thickness (r = 0.70, p < 0.001) displayed the strongest positive correlation.

Age range groups showed a negative correlation for visual acuity and anterior chamber depth and a positive correlation for CLT in linear increment values. The p-value for VA, ACD and CLT was nor statistically significant when compared among age range groups.

Discussion

Type 2 diabetes mellitus is a widespread metabolic disease characterized by chronic high blood sugar levels, which can progressively damage various body systems, including the eyes. Among the specific ocular structures affected, anterior chamber depth and crystalline lens thickness are particularly noteworthy, as these parameters influence the eye's refractive power.[9]

This study findings provide a comprehensive exploration of how glycaemic control, as measured by HbA1c levels, influences various ocular parameters in diabetic patients. By comparing our results with previous studies, we can better understand the trends, correlations, and potential discrepancies observed across different populations and methodologies.

The distribution of HbA1c levels in our study demonstrated that a substantial proportion of study patients had poor glycaemic control, with 76% falling into combined Group III (8.0-10.0%) and Group IV (>10.0%). This finding is consistent with Selvin et al. (2014)[10], who analysed a large diabetic cohort and reported that a significant proportion of patients struggled to maintain HbA1c below 7.0%, highlighting the challenges of long-term glycaemic control. This study further emphasized that persistent hyperglycemia is linked to a higher incidence of diabetic complications, including retinopathy, nephropathy, and neuropathy.

In our study a moderate negative correlation was observed between mean HbA1c and mean decimal visual acuity, indicating that poorer glycaemic control is associated with worse visual function. We also found that this negative correlation was gradually progressive in relation to the rise in HbA1c levels. This aligns with the well-documented effects of diabetic retinopathy (DR), which progressively deteriorates vision over time. Similar to our observations Wisconsin Epidemiologic Study of Diabetic Retinopathy (WESDR) conducted by Klein et al. (1989)[1] reported that higher HbA1c levels significantly increased the risk of developing diabetic retinopathy, with a 10-year incidence rate of 27% in patients with HbA1c>9.0%. Matza et al. (2008)[11] conducted a similar 10-year longitudinal study (n=600) and found that patients with HbA1c <7.0% had a 48% lower risk of developing vision-threatening retinopathy compared to those with HbA1c >9.0%.

Present study analysed a moderate gradual linear rising negative correlation (study group I between mean HbA1c and mean value of anterior chamber depth (ACD), suggesting that chronic hyperglycemia may contribute to structural changes in the anterior segment of the eye, potentially increasing the risk of angle-closure glaucoma (ACG). Similar to our analysis Saw et al. (2007)[4] reported a strong negative correlation with highly significant in a sample of 320 patients. They also concluded that diabetic patients had shallower anterior chambers compared to non-diabetics, predisposing them to ACG. However, in contrast to our analysis Adeoti c et al. (2012)[12] (n=150) did not find a significant correlation, although it was also negative correlation) between the HbA1c levels and ACD and they also found a non-significant statistical relation between these values. These observations were possibly due to the differences in study designs, sample size, or ethnic variations.

Our study found a moderate positive correlation with statistically significant between mean HbA1c and mean crystalline lens thickness (CLT), highlighting the impact of poor glycaemic control on lens morphology. This is consistent with the hypothesis that chronic hyperglycemia leads to osmotic changes and sorbitol accumulation within the lens, resulting in lenticular swelling and increased thickness. Man et al. (2013)[13] proposed that hyperglycemia-induced sorbitol accumulation within the lens causes osmotic swelling, leading to increased thickness and contributing to diabetic cataracts.

Similar to our findings Teberik et al. (2018)[14] (n=400) and Wong et al. (2006)[15] (n=350) also found a significant positive correlation, between HbA1c and lens thickness, supporting the idea that higher glucose levels exacerbate lenticular changes. In contrast, Klein et al. (1998)[1] (n=200) did not find a significant correlation, suggesting variability in the relationship based on population characteristics or measurement techniques.

These findings emphasize the need for routine ophthalmologic screenings in diabetic care, particularly for patients with HbA1c >8.0%. Poor glycaemic control (HbA1c >8.0%) is prevalent in diabetic populations, leading to an increased risk of diabetic retinopathy, cataracts, and angle-closure glaucoma. Visual acuity deteriorates with higher HbA1c levels, as confirmed by the WESDR and other longitudinal studies. Anterior chamber depth is reduced in diabetic patients, increasing the risk of angle-closure glaucoma, as supported by multiple studies. Crystalline lens thickness increases with worsening glycaemic control, reinforcing the link between hyperglycemia and diabetic cataracts. Patient education on glycaemic control should be strengthened, with a focus on its direct impact on vision and ocular health. Future studies should focus on longitudinal tracking of ocular changes in diabetic patients, with larger and more diverse sample sizes to clarify conflicting results.

Conclusion

This study gives valuable insights into the detrimental effects of poor glycaemic control on ocular health in diabetic patients. The significant correlations between HbA1c levels and key ocular parameters highlight the need for early detection, routine ophthalmologic evaluations, and stringent glycaemic control as essential components of diabetes management. Healthcare providers should integrate these findings into clinical practice by emphasizing regular eye examinations and individualized diabetes management strategies to decrease the burden of vision impairment. By prioritizing glycaemic control and ophthalmologic care, we can enhance long-term visual outcomes and improve the overall quality of life for patients.

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Legend Tables and Figures

Table 1: HbA1c level based study group wise distribution of patients

Study Groups (HbA1c level range)	Study Patients n (%)	HbA1c value Mean ± SD
Group I (6.5 -7.0%)	6 (7.05%)	6.72 ± 0.18
Group II (7.0 -8.0%)	14 (16.47%)	7.34 ± 0.31
Group III (8.0 -10.0%)	36 (42.35%)	8.80 ± 0.54
Group IV (>10.0%)	29 (34.11%)	11.00 ± 0.56
SD: standard deviation, n: Number of patients		

Table 2: Correlation of HbA1c groups with mean VA, ACD and CLT

HbA1c study groups	Mean VA		Mean ACD		Mean CLT	
	(r)	p-value	(r)	p-value	(r)	p-value
Group I (6.5 - 7.0%)	-0.42	0.003	-0.35	0.012	0.39	0.007
Group II (7.0 - 8.0%)	-0.51	<0.001	-0.48	<0.001	0.53	<0.001
Group III (8.0 - 10.0%)	-0.6	<0.001	-0.55	<0.001	0.58	<0.001
Group IV (>10.0%)	-0.72	<0.001	-0.65	<0.001	0.7	<0.001
Total Mean	-0.6	<0.001	-0.58	0.00177	0.65	0.00393
r: Pearson correlation constant, VA: visual acuity, ACD: Anterior chamber depth, CLT: Crystalline lens thickness						

Table 3: Statistical correlation analysis of mean HBA1c values with mean RBS, visual acuity, ACD and CLT using Pearson constant along with respective interpretations

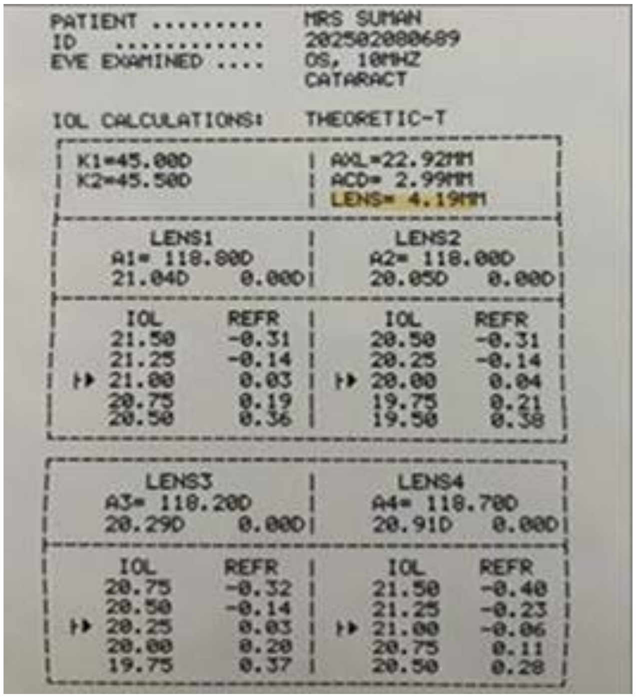
	Pearson Correlation (r)	p-value	Interpretation
Mean HbA1c vs. Mean Random Blood Sugar (RBS)	0.93	0.00142	Strong Positive Correlation (Statistically Significant)
Mean HbA1c vs. Mean Decimal Visual Acuity	- 0.6	<0.001	Moderate Negative Correlation (Statistically Significant)
Mean HbA1c vs. Mean Anterior Chamber Depth (ACD)	- 0.58	0.00177	Moderate Negative Correlation (Statistically Significant)
Mean HbA1c vs. Mean Crystalline Lens Thickness (CLT)	0.65	0.00393	Moderate Positive Correlation (Statistically Significant)

Table 4: Correlation of Age groups with mean VA, ACD and CLT

Age Groups (years)	Visual Acuity		Anterior Chamber Depth		Crystalline lens thickness	
	Pearson Correlation (r)	p-value	Pearson Correlation (r)	p-value	Pearson Correlation (r)	p-value
45-55	-0.4	0.15	-0.3	0.13	0.35	0.14

56-65	-0.45	0.18	-0.35	0.17	0.4	0.16
66-75	-0.5	0.11	-0.4	0.12	0.45	0.125
>76	-0.6	0.095	-0.5	0.1	0.55	0.105
Total Mean	-0.48	0.135	-0.38	0.13	0.44	0.132

Figure 1 A: Amplitude scan showing lens thickness in mm (highlighted)



PATIENT .... MRS SUMAN
ID 202502080689
EYE EXAMINED .... OS, 10MHZ
CATARACT

IOL CALCULATIONS: THEORETIC-T

K1=45.00D | AXL=22.92MM
K2=45.50D | ACD= 2.99MM
| LENS= 4.19MM

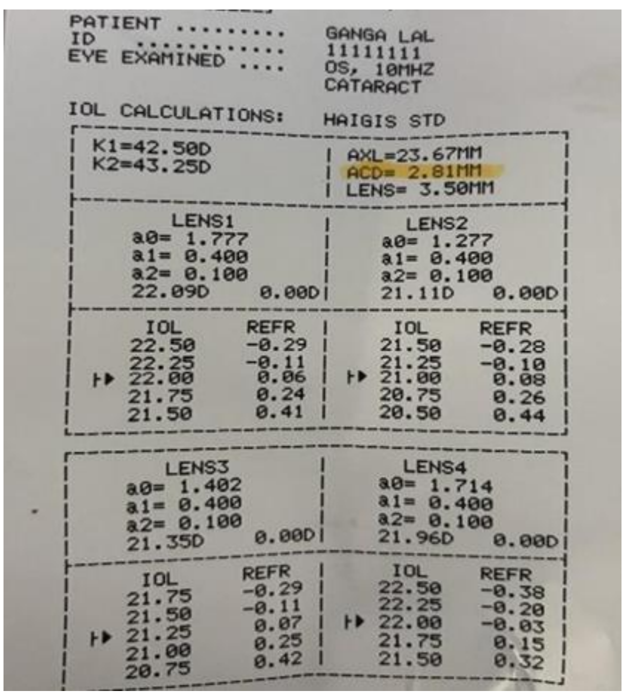
LENS1 | LENS2
A1= 118.80D | A2= 118.00D
21.04D 0.00D | 20.05D 0.00D

IOL REFR | IOL REFR
21.50 -0.31 | 20.50 -0.31
21.25 -0.14 | 20.25 -0.14
21.00 0.03 | 20.00 0.04
20.75 0.19 | 19.75 0.21
20.50 0.36 | 19.50 0.38

LENS3 | LENS4
A3= 118.20D | A4= 118.70D
20.29D 0.00D | 20.91D 0.00D

IOL REFR | IOL REFR
20.75 -0.32 | 21.50 -0.40
20.50 -0.14 | 21.25 -0.23
20.25 0.03 | 21.00 -0.06
20.00 0.20 | 20.75 0.11
19.75 0.37 | 20.50 0.28

Figure 1 B: Amplitude scan showing anterior chamber depth in mm (highlighted)



PATIENT .... GANGA LAL
ID 11111111
EYE EXAMINED .... OS, 10MHZ
CATARACT

IOL CALCULATIONS: HAIGIS STD

K1=42.50D | AXL=23.67MM
K2=43.25D | ACD= 2.81MM
| LENS= 3.50MM

LENS1 | LENS2
a0= 1.777 | a0= 1.277
a1= 0.400 | a1= 0.400
a2= 0.100 | a2= 0.100
22.09D 0.00D | 21.11D 0.00D

IOL REFR | IOL REFR
22.50 -0.29 | 21.50 -0.28
22.25 -0.11 | 21.25 -0.10
22.00 0.06 | 21.00 0.08
21.75 0.24 | 20.75 0.26
21.50 0.41 | 20.50 0.44

LENS3 | LENS4
a0= 1.402 | a0= 1.714
a1= 0.400 | a1= 0.400
a2= 0.100 | a2= 0.100
21.35D 0.00D | 21.96D 0.00D

IOL REFR | IOL REFR
21.75 -0.29 | 22.50 -0.38
21.50 -0.11 | 22.25 -0.20
21.25 0.07 | 22.00 -0.03
21.00 0.25 | 21.75 0.15
20.75 0.42 | 21.50 0.32

Figure 2: Distribution of number of patients with percentage in various study groups as per HbA1c ranges

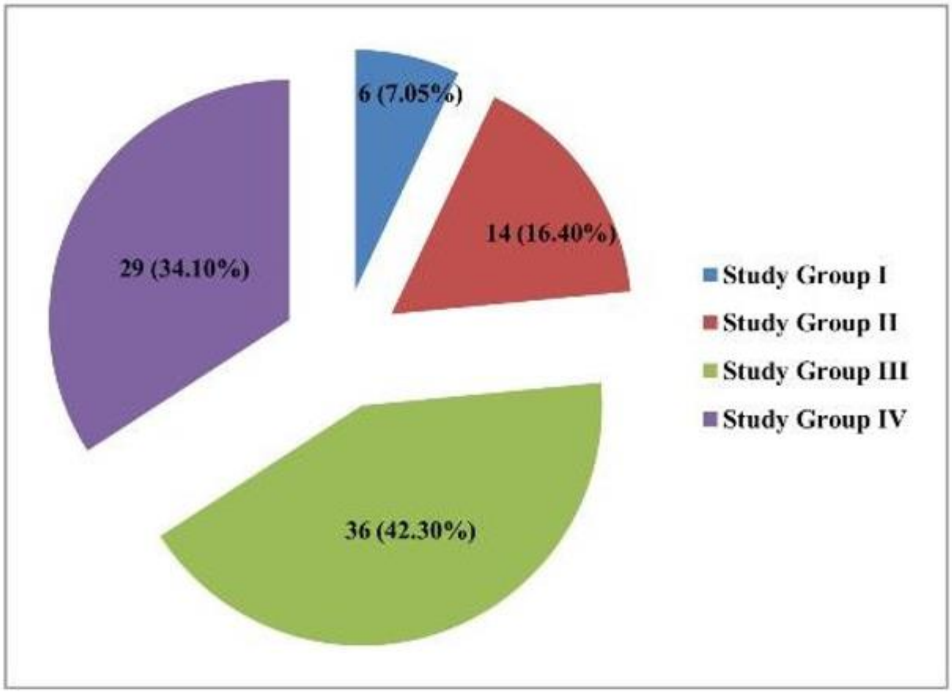


Figure 3: Comparison of mean HbA1c values in various study groups

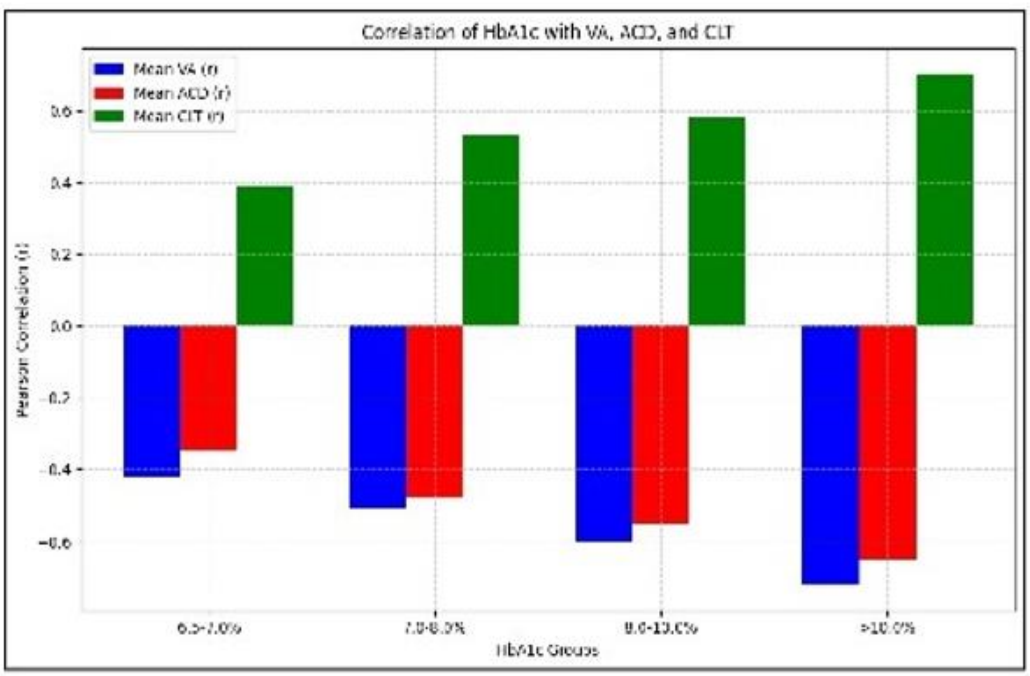


Figure 4: Correlation of mean HbA1c values of various HbA1c study groups with the mean visual acuity, anterior chamber depth and crystalline lens thickness