Original Article

Diabetic Macular Oedema in Diabetic Patients Attending the Endocrinology Clinic at University College Hospital, Ibadan

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Abstract

Background: Diabetic macular oedema (DME), a significant threat to vision among diabetics, often eludes the early detection due to patients' delayed ophthalmologist visits. Our efforts to increase screening participation through physician referral promotion and cost reduction have not yielded significant results. Faced with the persistent challenge of low screening rates, we sought to explore innovative alternatives to increase DME detection. The first involved implementing ophthalmologist-led screening programmes, while the second focused on promoting sponsored on-site screenings at diabetic clinics. These strategies aim to integrate DME screenings more seamlessly into routine diabetes management, potentially increasing the likelihood of early detection. By making screenings more convenient and readily available within existing care pathways, we anticipate these approaches could significantly improve participation rates and consequently lead to earlier intervention for DME amongst diabetic patients. **Aim:** To determine the prevalence of DME in visually asymptomatic diabetic patients through comprehensive screening and to evaluate the potential benefits of early detection in improving the visual outcomes and patient care. **Methods:** A cross-sectional study was conducted from 2020 to 2023, involving 225 consecutive diabetic patients who consented to participate while attending the diabetic clinic. The Joint University of Ibadan/University College Hospital Institutional Review Board provided ethical approval for the research. The study collected the data on patient demographics and medical history. Thereafter, they underwent comprehensive ocular examinations. All findings were systematically documented for analysis using the IBM Statistical Package for the Social Sciences software version 26.0. **Results:** A total of 225 diagnosed diabetic patients (450 eyes) were examined in the study. The duration of diabetes mellitus amongst participants ranged from two months to 30 years. The sex distribution shows a male-to-female ratio of 1:2.6, indicating a higher proportion of female participants. The age range of the study population is 31–87 years. Regarding diabetic control, 32% of participants had a fasting blood sugar (FBS) level higher than 120 mg/dL. Visual acuity (VA) assessments revealed that 16.9% ($n = 38$) of participants had VA worse than 6 / 12. Out of the total participants, 42 (18.9%) had DME in at least one eye, while 180 (81.1%) had no DME. DME was observed in 32 right eyes (14.7%) and 32 left eyes (14.9%). A statistically significant association was found between DME and visual impairment ($\chi^2 = 11.2$, $P = 0.001$), with a higher proportion of DME patients (33.3%) having visual impairment compared to those without DME (13.1%). Patients with DME were 3.6 times more likely to have best-corrected VA worse than 6 / 12 in the better eye compared to those without DME. **Conclusion:** This study reveals a significant prevalence of DME and its strong association with visual impairment. Our findings underscore the need to take screening services directly to diabetic clinics and the urgency of implementing routine eye screening protocols for all diabetic patients in our medical facilities to enable the early detection and timely intervention.

Keywords: Diabetic macular oedema, screening, visual impairment

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Introduction

Diabetes mellitus (DM) has become a formidable global health issue, with its incidence increasing significantly across both industrialised and emerging nations. An estimated 537 million adults currently have diabetes and experts forecast this figure will rise to 783 million by the year 2045, with low- and middle-income countries being most affected.[1] The situation in Africa is particularly distressing, with projections indicating a 134% surge in diabetic adults, from 24 million in 2021 to

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DOI:
10.4103/NJM.NJM_75_24

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How to cite this article: Oluleye TS, Babalola YO, Majekodunmi OI, Ijaduola MA, Fasanmade AA, Alonge TO, *et al*. Diabetic macular oedema in diabetic patients attending the endocrinology clinic at University College Hospital, Ibadan. Niger J Med 2024;33:151-7.

Submitted: 10-Aug-2024 **Revised:** 16-Oct-2024
Accepted: 18-Oct-2024 **Published:** 06-Jan-2025

around 55 million by 2045.[1] In Nigeria, the prevalence of diabetes among adults aged 20–79 years was estimated to be 3.7% in 2021, which is equivalent to 3.6 million people. This number is also projected to increase by 67% to 6 million by the year 2045.[1] These frightening statistics underscore the critical nature of DM in sub-Saharan Africa.

Diabetic macular oedema (DME) represents a critical intersection of two global health crises: diabetes and vision impairment. As a severe complication of DM, DME poses a significant threat to vision and quality of life for millions worldwide. The global prevalence of DME amongst diabetic patients, ranging from 2.7% to 11%,[2] underscores the magnitude of this challenge. This wide variation in prevalence rates reflects not only differences in diabetic populations but also stark disparities in healthcare access and quality across the different regions.

In developing countries such as Nigeria, the prevalence of DME tends to be higher due to a complex interplay of factors. The combination of limited healthcare access, exorbitantly high costs of care, and delayed diagnoses fosters an ideal environment for the progression of diabetic eye complications, leaving many patients vulnerable to worsening conditions.[3] This situation is further exacerbated by a widespread lack of public awareness about the critical importance of regular eye examinations for diabetic patients, resulting in missed opportunities for early intervention. Ideally, endocrinologists should refer every patient diagnosed with diabetes for eye examinations, regardless of whether they have visual complaints. However, in many cases, there is no policy mandating this practice, and even where such policies exist, the health system often fails to enforce them or hold non-compliant healthcare providers accountable. The absence of standardised referral protocols and enforcement mechanisms leads to additional gaps in care, which further hinder the early detection and treatment of diabetic eye complications.

Furthermore, the consequences of untreated or poorly managed DME extend far beyond visual impairment. Patients face a cascade of negative outcomes, including irreversible vision loss, which can profoundly impact their independence, employment prospects and overall quality of life. The economic burden and loss of productivity stemming from visual impairment and blindness are substantial, impacting both individuals and healthcare systems. The costs associated with managing advanced eye disease and its complications significantly exceed those of preventive care and early treatment, underscoring the importance of timely intervention in eye health.[4]

Therefore, regular screening for the early detection of DME is crucial for improving visual outcomes, underscoring the urgent need for comprehensive and accessible eye care programmes, especially in resource-limited settings like ours. Proactive DME screening is vital in confronting these hurdles. Typical screening protocols involve comprehensive dilated eye examinations, optical coherence tomography (OCT) and fundus photography.[5]

Implementing such robust screening protocols can help identify and manage DME in its early stages, potentially averting severe vision loss and reducing the overall burden of diabetic eye complications. In our context, where healthcare resources are often stretched thin, prioritization and investment in robust screening initiatives and access to eye care services is needed. This can result in significant strides in reducing the burden of DME and its associated complications. This proactive approach to reducing the burden of DME and its associated complications will not only enhance the quality of life for individual patients but also has the potential to reduce long-term healthcare costs and alleviate the societal impact of vision impairment like increased dependency and isolation.

Methods

An observational and cross-sectional study was conducted amongst clinically diagnosed diabetic patients being managed by the Endocrinology Unit at University College Hospital, Ibadan, Nigeria, between January 2020 and December 2023. Ethical approval was obtained from the Joint University of Ibadan/University College Hospital Institutional Review Board. For all patients attending this clinic, informed consent was taken before data collection and screening.

Initial screening of all patients presenting to the endocrinology clinic was conducted utilising a standardised miniquestionnaire. Subjects who demonstrated no ocular complaints were subsequently enrolled in the study protocol. Conversely, patients reporting visual symptoms were appropriately counselled and expeditiously referred to the ophthalmology clinic, where pre-determined arrangements facilitated immediate consultation and clinical management. Thereafter, the recruited study participants were further interviewed and the information was recorded into a pre-designed data sheet. Parameters measured included fasting blood glucose (mmol/L), body mass index (BMI) (kg/m^2) and blood pressure (mmHg). Visual acuity (VA) was assessed best corrected where appropriate using a Snellen vision chart at a distance of

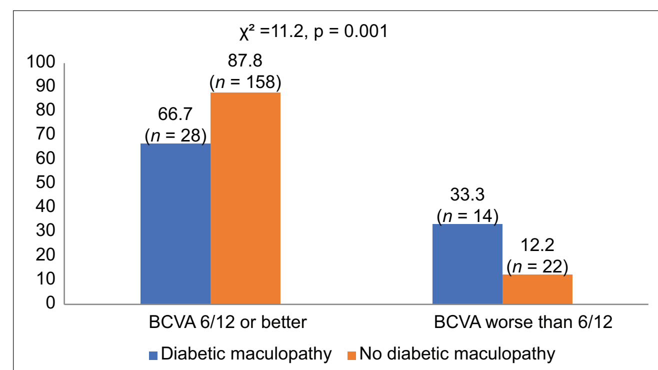

Figure 1: Distribution of visual acuity disaggregated by diabetic maculopathy status. BCVA: Best-corrected visual acuity

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6 m. Both eyes were then dilated using tropicamide 1% plus phenylephrine 2.5% eyedrops.

A vitreo-retinal surgeon graded for diabetic retinopathy (DR) and maculopathy using the DR grading system as per the UK National Health Service screening programme [Table 1].[6] An initial macula examination was performed using Haag-Streit slit-lamp biomicroscope (BM 900) with a Volks +78D lens. This visual examination was followed by capturing a digital image of the retina using a Canon digital retinal camera (Ref: CR – 2 PLUS AF), and an objective assessment of the retina using spectral domain Optovue OCT (Ref: iVue 100), to provide cross-sectional images of the macula.

This comprehensive approach ensured a thorough evaluation of the macula and surrounding areas, facilitating accurate diagnosis.

The prevalence of diabetic maculopathy was then calculated individually for the right eye, left eye and considering the worse of either eye. Where patients were identified to have ocular complications during our study, they were referred for onward treatment.

The collected data were input into IBM SPSS Statistics for Windows, Version 26.0. (IBM Corp., Armonk, NY), running on Windows 10. For the continuous variables, results were expressed as mean ± standard deviation. The categorical variables were reported as frequencies and percentages. A nested case–control analysis was performed to estimate the odds ratios (ORs) and 95% confidence intervals (CIs) for the demographic and lifestyle factors, the relevant medical conditions and the exposures associated with diabetic maculopathy. A multivariable unconditional binary logistic regression was created for each variable of interest, adjusting for age, gender and duration of diabetes. $P < 0.05$ was considered statistically significant.

Results

A total of 225 patients with diabetes were included in the study. The mean age of the participants was 61.6 (±10.5) years, with 57 (25.3%) being male. Demography and overview of clinical characteristics of included patients are shown in Table 2.

For individual eyes, 185 (82%) right eyes and 183 (82%) left eyes had no DME. Conversely, 32 (14%) right eyes and 32 (15%) left eyes had DME. Eight right eyes and 10 left eyes, respectively were ungradable for maculopathy due to media opacities (corneal scar and cataract).

Out of the total participants, 180 individuals (81.1%) had no DME (M0) in either eye. Conversely, 42 individuals (18.9%) were found to have DME (M1) in at least one eye. There were three participants who had ungradable eyes bilaterally and were excluded from further analysis [Table 3].

A binary logistic regression analysis was conducted to identify the factors associated with the presence of DME in this cohort. The analysis considered several variables, including age, gender, estimated duration of diabetes diagnosis, BMI, fasting blood sugar (FBS), prior cataract surgery and the presence and severity of hypertension. The three patients who had ungradable eyes bilaterally were excluded from this analysis.

The initial univariable analysis did not identify any significant associations between the demographic or clinical characteristics and the occurrence of DME [Table 4]. This analysis included examining each variable independently without adjusting for potential confounders.

Table 1: Diabetic maculopathy grading protocol

M0	No visible maculopathy	No maculopathy features
M1	Maculopathy	Exudate within 1 DD of the fovea centre Circinate or group of exudates within the macula Retinal thickening within 1 DD of the centre of the fovea
U	Maculopathy ungradable	Small vessels of macula not clearly visible

DD: Disc diameter

Table 2: Demographic profile and clinical overview of diabetic patients

Characteristic	Diabetic
Age (years), mean±SD	61.6±10.5
Gender, *n* (%), males	57 (25.3)
Duration of diabetes (years), mean±SD	11.9±8.3
Cataract surgery in either eye, *n* (%)	20 (8.9)
Blood glucose	
Fasting blood glucose (mmol/L), mean±SD	114.6±31.3
Missing FBS data, *n* (%)	13 (5.8)
Hypertension status (mmHg), *n* (%)	
Normal (<120 systolic and <80 diastolic)	48 (21.3)
Pre-hypertension (120–139 systolic or 80–89 diastolic)	95 (42.2)
Hypertension stage 1 (140–159 systolic or 90–99 diastolic)	54 (24.0)
Hypertension stage 2 (≥160 systolic or≥100 diastolic)	28 (12.4)
Missing data, *n* (%)	0
BMI (kg/m²), *n* (%)	
<25	94 (41.8)
25–39	83 (36.9)
≥30	48 (21.3)
Missing data, *n* (%)	0

*Unless otherwise stated, the total number of valid cases for each characteristic is 225. Missing data are specified where applicable.
BMI: Body mass index, SD: Standard deviation, FBS: Fasting blood sugar

Table 3: Distribution of diabetic macula oedema amongst the participants

Diabetic maculopathy grade	Either eye, *n* (%)	Right eye, *n* (%)	Left eye, *n* (%)
No DME (M0)	180 (81.1)	185 (85.3)	183 (85.1)
DME (M1)	42 (18.9)	32 (14.7)	32 (14.9)
Maculopathy ungradable (U)	3	8	10
Total	225 (100.0)	225 (100.0)	225 (100.0)

DME: Diabetic macular oedema

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Table 4: Comparison of demographic and clinical characteristics between non-diabetic macular oedema patients and diabetic macular oedema cases and their association with diabetic macular oedema occurrence (n=222)

	Non-DME patients (n=180), n (%)	DME cases (n=42), n (%)	Unadjusted OR	OR[a] (95% CI)
Male	46 (25.6)	9 (21.4)	0.96 (0.50–1.85)	0.77 (0.34–1.72)
Age more than 60 years	101 (56.1)	25 (59.5)	1.15 (0.58–2.28)	0.99 (0.48–2.04)
Duration of DM more than 10 years	78 (43.3)	23 (54.8)	1.58 (0.81–3.11)	1.56 (0.76–3.23)
BMI (kg/m^2)				
<25	76 (42.2)	16 (38.1)	Reference	Reference
25–39	64 (35.6)	18 (42.9)	0.75 (0.35–1.59)	0.69 (0.32–1.49)
≥30	40 (22.2)	8 (19.0)	1.05 (0.42–2.67)	1.00 (0.39–2.57)
FBS >120 mg/dL	59 (35.1)	13 (31.7)	0.86 (0.41–1.78)	0.89 (0.42–1.86)
Normal BP (≥120 systolic or ≥80 diastolic)	139 (77.2)	35 (83.3)	1.48 (0.61–3.57)	1.44 (0.59–3.51)
Prior cataract surgery	14 (7.8)	5 (11.9)	1.60 (0.54–4.72)	1.46 (0.46–4.57)

[a]Adjusted for age, duration of diabetes. BMI: Body mass index, CI: Confidence interval, DME: Diabetic macular oedema, OR: Odds ratio, DM: Diabetes mellitus, BP: Blood pressure, FBS: Fasting blood sugar

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Similarly, in a multivariable logistic regression performed to adjust for confounding factors, specifically age and duration of diabetes, none of the examined demographic or clinical characteristics showed a significant association with the occurrence of DME [Table 4].

Amongst the total diabetic patients, 38 (16.9%) had best-corrected VA (BCVA) worse than 6 / 12 in the better eye [Table 5]. Patients with DME in either eye were significantly more likely to have visual impairment compared to those without DME [Figure 1]. Specifically, 38.9% of patients with visual impairment had DME, while only 15.1% (28 / 187) of those without visual impairment had DME [Table 6]. Logistic regression analysis showed that patients with DME in either eye were 3.59 times more likely to have visual impairment than those without DME (unadjusted OR =3.59, 95% CI: 1.64–7.84, P = 0.002). After adjusting for age and duration of diabetes, the association between DME and visual impairment remained significant (adjusted OR =3.53, 95% CI: 1.58–7.88, P = 0.002). There were no statistically significant differences in gender, age or duration of diabetes between patients with and without visual impairment [Table 6].

Discussion

The results of our study indicate a worrisome occurrence of DME, impacting 18.9% of the individuals involved in the study. This rate is significantly higher than the previous rates of 5.5%,[7] 6.8%[2] and 3.8%[8] and 9%.[9] The significant contrast emphasises the potential variation in the prevalence of DME amongst different populations and reinforces the significance of conducting studies specific to each region. Although our findings are significantly high, they are not completely unique. A study carried out in Ethiopia reported a DME prevalence of 17%[10] which, although slightly lower than our results, still suggests a substantial burden of the condition. These findings highlight the increasing worldwide impact of DME and emphasise the urgent requirement for early detection strategies and prompt treatment interventions. Interestingly, our study did not find significant associations between DME occurrence and various demographic or clinical characteristics. This outcome contrasts with established research such as the Wisconsin Epidemiologic Study of DR, which has previously identified several risk factors for DME, including longer diabetes duration and the presence of hypertension.[11] This inconsistency underscores the intricate nature of DME and highlights the critical need for population-specific studies to inform the development and implementation of tailored screening protocols, prevention strategies and related policies.

A particularly noteworthy aspect of our study is the identification of DME in diabetic patients who reported no apparent ocular symptoms. This phenomenon, often referred to as 'subclinical' or 'asymptomatic' DME, presents a significant challenge in diabetic eye care. Our investigation revealed a notable 18.9% prevalence of DME amongst study participants, with representative fundus photography and OCT imaging findings illustrated in Figures 2-4. Remarkably, many affected individuals were unaware of any visual changes, highlighting DME's silent progression. This observation aligns with similar studies, reinforcing our understanding of DME's subtle onset and prevalence in the diabetic population.[12-15] The high occurrence of asymptomatic DME is concerning, suggesting that many diabetic patients may have undetected retinal changes. This can lead to critical delays in essential treatment. Delayed DME management often necessitates more intensive interventions, including increased intravitreal anti-vascular endothelial growth factor injections, steroid treatments and focal laser therapy sessions. These aggressive treatments become necessary due to the development of chronic oedema and irreversible retinal changes over time.[16,17]

The occurrence of asymptomatic DME underscores the critical importance of regular, comprehensive ophthalmological examinations for all diabetes patients, regardless of perceived visual changes. Early detection of DME, even in its subclinical stages, may enable timely interventions, potentially mitigating or preventing vision loss.[18] This finding supports the integration of advanced imaging modalities, such as OCT, into routine diabetic eye screenings.[19] For example, our study identified

DME in eyes that appeared normal or had media opacity during dilated fundus examination using a slit lamp biomicroscope and +78D lens [Figures 5 and 6]. This highlights the limitations of conventional examination techniques in detecting subtle retinal changes associated with DME. Advanced imaging techniques like OCT can reveal subtle retinal alterations that may elude detection through conventional ocular examinations or remain imperceptible to the patient.

Our study revealed a robust association between DME and visual impairment, with 16.9% of study participants exhibiting BCVA worse than 6 / 12 in their better eye. This observation may expose these patients to waning quality of life as reported in the Los Angeles Latino Eye Study,[20] which linked DME to reduced visual functioning and vision-related quality of life. Notably, our study demonstrated a statistically significant correlation between DME and visual impairment, with an OR of 3.6.

Table 5: Distribution of visual acuity amongst participants (*n*=225)

	Frequency	Prevalence
BCVA 6/12 or better	187	83.1
BCVA worse than 6/12–6/18	16	7.1
BCVA worse than 6/18–6/60	18	8.0
BCVA worse than 6/60–3/60	3	1.3
BCVA worse than 3/60	1	0.4

BCVA: Best-corrected visual acuity

These findings carry several important implications. First, DME significantly compromises patients' VA, adversely affecting overall visual function. Second, the resultant visual impairment can substantially diminish the quality of life. Third, the early identification and treatment of DME could potentially prevent severe visual impairment, emphasising the paramount importance of early detection. Finally, given the rising global prevalence of DM, DME may perhaps emerge as a major contributor to the global burden of visual impairment and blindness, highlighting its significant public health consequences.

Limitations of the study

Fasting blood sugar (FBS), although useful, reflects short-term glucose levels, unlike glycated haemoglobin (HbA1c), which would better capture chronic hyperglycaemia's role in DME. The absence of FBS data for 5.8% of participants further compounds this limitation.

The cross-sectional design of this study limits causal inferences, and the clinic-based sampling may restrict the generalisability of results.

Technical challenges, such as media opacities, resulted in some eyes being ungradable, potentially skewing the data.

A particularly notable limitation is the wide age range of participants (31–87 years), which introduces significant heterogeneity. While multivariable regression models

Table 6: Associations between demographic and clinical factors and visual impairment (*n*=225)

	No visual impairment (*n*=187), *n* (%)	Visual impairment (*n*=38), *n* (%)	Unadjusted OR	OR[a] (95% CI)
DME in either eye	28 (15.1)	14 (38.9)	3.59 (1.64–7.84)**	3.53 (1.58–7.88)**
Male	46 (24.6)	11 (28.9)	1.25 (0.58–2.71)	0.95 (0.40–2.28)
Age more than 60 years	102 (54.5)	26 (68.4)	1.81 (0.86–3.79)	1.42 (0.61–3.35)
Duration of diabetes more than 10 years	81 (43.3)	22 (57.9)	1.80 (0.89–3.65)	1.43 (0.67–3.07)

***P*<0.05 statistically significant. [a]Adjusted for age, duration of diabetes, and DME in either eye significant. CI: Confidence interval, DME: Diabetic macular oedema, OR: Odds ratio

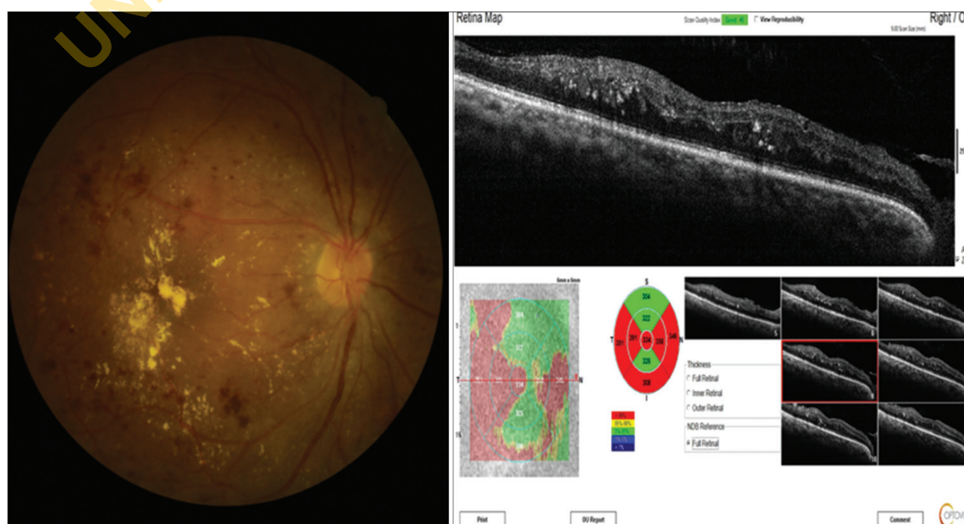

Figure 2: Images of diabetic macular oedema found amongst study population

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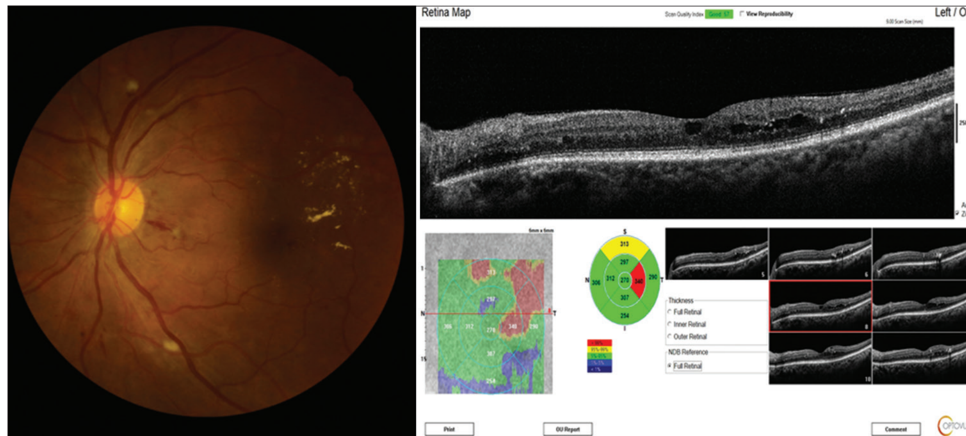

Figure 3: Centre involving diabetic macula edema among the study population

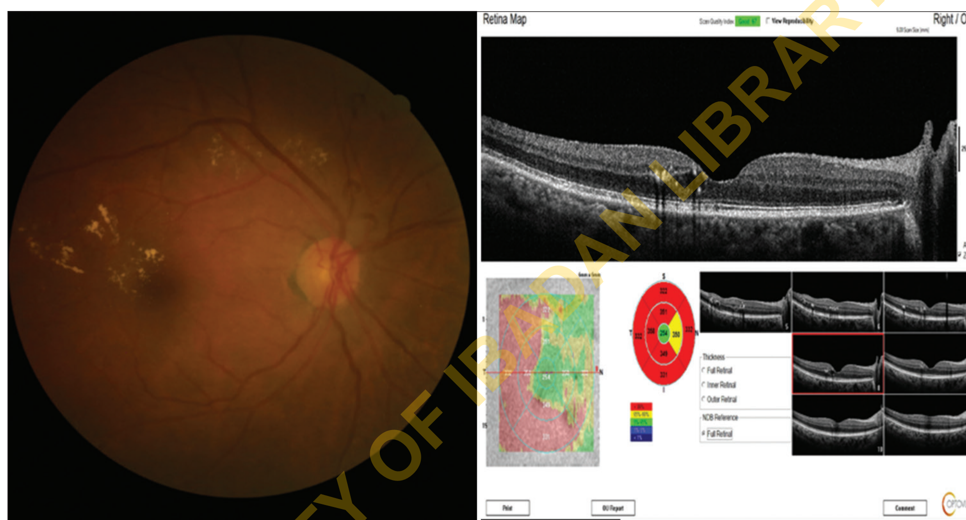

Figure 4: Centre involving diabetic macula edema

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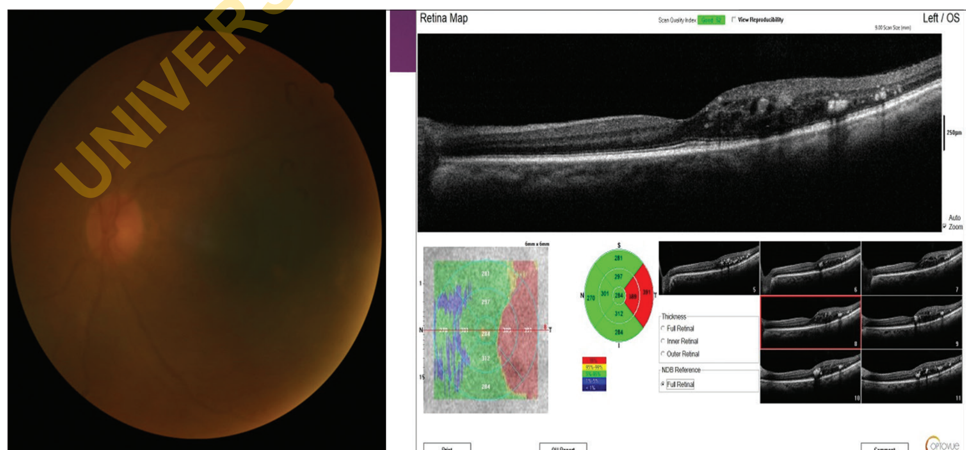

Figure 5: Ungradable photograph due to lens opacity gradable with optical coherence tomography

attempted to mitigate systematic bias, residual confounding remains a concern, especially if age interacts non-linearly with outcomes or other variables like diabetes duration.

The study's treatment of DME as a binary outcome (M0/M1) simplifies analysis but overlooks the nuances of DME severity. Examining this severity in relation to diabetes control and other factors could have provided more detailed insights but was beyond the current study's scope.

Future studies should consider longitudinal designs, use HbA1c for long-term glucose assessment and explore DME severity in

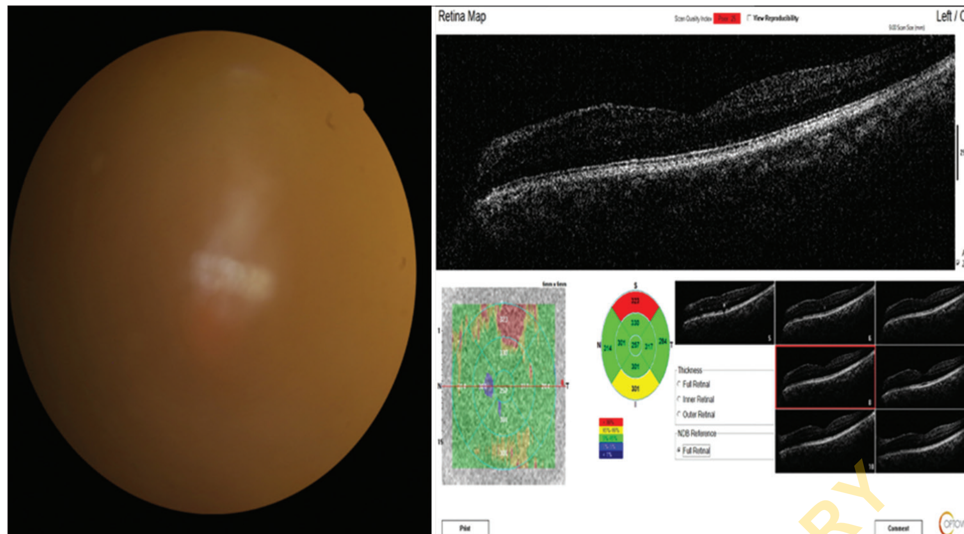

Figure 6: Ungradable photograph gradable with optical coherence tomography

relation to various factors. This approach would provide a more comprehensive understanding of the relationships between age, diabetes control and DME development over time.

Conclusion

Our study reveals a high DME prevalence in visually asymptomatic diabetics, emphasising its link to vision loss and necessitating a reassessment of screening protocols. The key steps include integrating eye screenings into diabetic care centres, securing funding for regular comprehensive examination and educating patients about DME risks and the importance of routine checks. Furthermore, healthcare policies need to be adopted to mandate eye screenings in diabetes management programs and incentivise providers to incorporate these services. Implementing these strategies can significantly reduce DME-related visual impairment, thus enhancing the diabetic patients' quality of life.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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References

1. International Diabetes Federation. IDF Diabetes Atlas. 10th ed. Belgium: International Diabetes Federation; 2021.
2. Yau JW, Rogers SL, Kawasaki R, Lamoureux EL, Kowalski JW, Bek T, *et al.* Global prevalence and major risk factors of diabetic retinopathy. Diabetes Care 2012;35:556-64.
3. Ciulla TA, Amador AG, Zinman B. Diabetic retinopathy and diabetic macular edema: Pathophysiology, screening, and novel therapies. Diabetes Care 2003;26:2653-64.
4. Burgess PI, MacCormick IJ, Harding SP, Bastawrous A, Beare NA, Garner P. Epidemiology of diabetic retinopathy and maculopathy in Africa: A systematic review. Diabet Med 2013;30:399-412.
5. World Health Organization. Diabetic Retinopathy Screening: A Short Guide. Increase Effectiveness, Maximize Benefits and Minimize Harm. Copenhagen: WHO Regional Office for Europe; 2020.
6. Harding S, Greenwood R, Aldington S, Gibson J, Owens D, Taylor R, *et al*. Grading and disease management in national screening for diabetic retinopathy in England and Wales. Diabet Med 2003;20:965-71.
7. Im JH, Jin YP, Chow R, Yan P. Prevalence of diabetic macular edema based on optical coherence tomography in people with diabetes: A systematic review and meta-analysis. Surv Ophthalmol 2022;67:1244-51.
8. Varma R, Bressler NM, Doan QV, Gleeson M, Danese M, Bower JK, *et al*. Prevalence of and risk factors for diabetic macular edema in the United States. JAMA Ophthalmol 2014;132:1334-40.
9. Wong TY, Klein R, Islam FM, Cotch MF, Folsom AR, Klein BE, *et al*. Diabetic retinopathy in a multi-ethnic cohort in the United States. Am J Ophthalmol 2006;141:446-55.
10. Kabtu E, Tsegaw A. Prevalence of diabetic macular edema and risk factors among diabetic patients at the University of Gondar Tertiary Eye Care and Training Center, North West Ethiopia. medRxiv 2022. p. 2022-04.
11. Klein R, Knudtson MD, Lee KE, Gangnon R, Klein BE. The Wisconsin epidemiologic study of diabetic retinopathy XXIII: The twenty-five-year incidence of macular edema in persons with type 1 diabetes. Ophthalmology 2009;116:497-503.
12. Ockrim Z, Yorston D. Managing diabetic retinopathy. BMJ 2010;341:c5400.
13. Fong DS, Aiello L, Gardner TW, King GL, Blankenship G, Cavallerano JD, *et al.* Diabetic retinopathy. Diabetes Care 2003;26 Suppl 1:S99-102.
14. Subasi ME, Patnaik S, Subasi A. Chapter 10 - Optical coherence tomography image classification for retinal disease detection using artificial intelligence. In: Subasi A, editor. Applications of Artificial Intelligence in Healthcare and Biomedicine: Academic Press; 2024. p. 289-323.
15. Sedova A, Hajdu D, Datlinger F, Steiner I, Neschi M, Aschauer J, *et al*. Comparison of early diabetic retinopathy staging in asymptomatic patients between autonomous AI-based screening and human-graded ultra-widefield colour fundus images. Eye (Lond) 2022;36:510-6.
16. Gangnon RE, Davis MD, Hubbard LD, Aiello LM, Chew EY, Ferris FL 3rd, *et al*. A severity scale for diabetic macular edema developed from ETDRS data. Invest Ophthalmol Vis Sci 2008;49:5041-7.
17. Song W, Singh RP, Rachitskaya AV. The effect of delay in care among patients requiring intravitreal injections. Ophthalmol Retina 2021;5:975-80.
18. Luu KY, Akhter MM, Durbin-Johnson BP, Moshiri A, Tran S, Morse LS, *et al*. Real-world management and long-term outcomes of diabetic macular oedema with good visual acuity. Eye (Lond) 2020;34:1108-15.
19. Kirkova R, Tanev I, Dimitrov T, Dimitrova T, Kirkov V. Application of optic coherence tomography as a screening in prevention and control of diabetic retinopathy. Pharmacia 2024;71:1-9.
20. Varma R, Bressler NM, Doan QV, Danese M, Dolan CM, Lee A, *et al*. Visual impairment and blindness avoided with ranibizumab in Hispanic and non-Hispanic whites with diabetic macular edema in the United States. Ophthalmology 2015;122:982-9.