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Study of serum magnesium levels in diabetic patients with and without retinopathy

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Abstract

Background: Diabetic retinopathy is a common microvascular complication of type 2 diabetics. Magnesium (Mg), a key intracellular electrolyte, which plays a pivotal role in glucose metabolism, insulin function, and vascular health. Its deficiency might be linked with metabolic disorders and microvascular complications including DR.

Aim of the Study: To assess serum Mg level in type 2 diabetes mellitus with and without diabetic retinopathy and to investigate its correlation with diabetic retinopathy.

Patients and Methods: This is a cross-sectional comparative study conducted at the Ophthalmology Center, Ghazi Al-Hariri Hospital for Surgical Specialties, Baghdad, Iraq, from March to August 2024. A total of 193 patients aged ≥ 40 years with type 2 diabetes mellitus were included, comprising 93 with diabetic retinopathy and 100 without. Serum magnesium and HbA1c levels were measured.

Results: Low serum magnesium was significantly more common in patients with diabetic retinopathy (29%) compared to those low Mg levels and both non-proliferative diabetic retinopathy ($p = 0.012$) and proliferative diabetic retinopathy ($p = 0.029$). However, no significant association was found between HbA1c or diabetes duration with Mg levels.

Conclusion: Serum magnesium deficiency is significantly associated with diabetic retinopathy in type 2 diabetics. However, magnesium levels were not significantly different between non-proliferative and proliferative cases.

Keywords: Diabetes mellitus, type 2, diabetic retinopathy, magnesium, hypomagnesemia, retinal diseases

Introduction

Diabetes mellitus implies major burden for healthcare systems throughout the world, with relentless increasing prevalence, especially in working-age adults [1]. In type 2 diabetes mellitus (T2DM), the prevalence of diabetic retinopathy after 10 years of its diagnosis is 67% and around 10% develops proliferative diabetic retinopathy (PDR) and a substantial percentage of patients are often unaware that they suffer from diabetic retinopathy [2].

Magnesium (Mg) is an electrolyte of pivotal physiological significance to humans, as it is second only potassium as a main intracellular electrolyte. Mg regulates cellular processes and is without DR (16%) ($p = 0.030$). Subgroup analysis showed a significant association between

associated in a wide range of metabolic reactions [3]. It's distributed in high concentrations in a wide variety of nuts, leafy green vegetables, and whole grains [4]. Previous works linked Mg deficiency to a number of health conditions like chronic diseases such as obesity, probably because of increased inflammation [5]. Supplementing Mg in type 2 diabetics decreased blood pressure and lipid levels while improving endothelial function, however, long-term magnesium supplementation studies are needed to determine whether increasing serum/plasma magnesium levels can improve cardiovascular outcomes [6].

In type 2 diabetes (T2DM) mellitus, Mg absorbing and retaining appears intact, while reduced intake and/or increased excretion via the kidneys are among the most important causes of its deficits [7]. Both increased glucose and insulin levels may increase urinary Mg excretion. In T2DM, Mg deficiency is usually seen as a chronic latent deficit without alterations in serum total Mg [8]. Mg is essentially important for normally secreting insulin, in addition for its role in maintaining numerous enzymatic functions related to glucose and energy metabolism, and its deficiency is associated with beta-cell dysfunction, insulin resistance, lower glucose tolerance, and ultimately, clinical manifestations of T2DM [9]. Supplementing Mg together with appropriate dietary patterns might decrease insulin resistance and enhance metabolic control in patients with T2DM [10].

Aim of the study: To assess serum Mg level in type 2 DM with and without diabetic retinopathy and to investigate its relation with diabetic retinopathy.

Patients and methods

Study design and setting: This was an observational cross-sectional comparative study conducted at The Ophthalmology center in Ghazi AL-Hariri Hospital for Surgical Specialties/ Baghdad/ Iraq, the data were collected from the 15th of March 2024 to the 30th of August 2024.

Inclusion criteria

Type II diabetic patients with or without diabetic retinopathy.

Age ≥ 40 years.

Exclusion criteria

Patients on any supplements containing Mg.

Other ocular conditions that might intervene with the results like glaucoma and previous ocular surgeries.

Patients on medications known to affect Mg levels, like diuretics, long term use of proton pump inhibitors, anti-epileptics, …. etc.

Patients who had a history of recent metabolic acidosis, renal complications of T2DM, other microvascular complications, severe inflammatory disease or infections.

Pregnant or lactating mothers

Type I diabetes mellitus

Sampling method: Convenient sampling of patients with 93 cases suffering from any sort of diabetic retinopathy (non-proliferative diabetic retinopathy, or proliferative diabetic retinopathy) and 100 cases who are diabetic without any retinal disease.

Examination and investigations: Patients diagnosed with T2DM were sent for a specialized ophthalmologist who examined the fundus of those patients to determine the presence of any signs for

diabetic retinopathy. Patients with diabetic retinopathy were classified according to the type and severity of their disease by the same ophthalmologist and were sent for Optical Coherence Topography (OCT) to record their central retinal thickness. Blood samples were collected from all participants for measurements of Hemoglobin A1c (HbA1c) and serum magnesium. Normal HbA1c ranges from 4.0%–5.6%, prediabetes from 5.7%–6.4%, while levels ≥ 6.4% levels have diabetes [11]. Serum Mg normal levels range from 1.7–2.4 mg/dL [12]. The demographic data were collected and included age, sex, residence, education, and occupation. Diabetes mellitus related data included: duration of the disease in years, type of medication whether oral antidiabetic medications or subcutaneous insulin.

Statistical analysis: Data analysis was done using Statistical Package for Social Sciences (SPSS) version 26. Descriptive statistics included frequency and percentage. Chi-square test was used to investigate the association between categorical variables. Independent samples T test was used to investigate the difference between two normally distributed variables, while Kruskal Wallis test was used to investigate the difference between more than two numerical variables that did not follow the normal distribution. A P-value less than 0.05 was considered significant.

Results

The current study enrolled 93 cases with diabetic retinopathy, their mean age was 55.6± 5.87 years and 100 cases without diabetic retinopathy, their mean age of 54.33± 6.82 years. There were 49(52.7%) males with diabetic retinopathy and 38(38%) males without diabetic retinopathy, patients with urban residence were 88(94.6%) with diabetic retinopathy and 91(91%) without diabetic retinopathy, primary education was the most prevalent in both groups with 52(55.9%) with diabetic retinopathy and 30(30%) without diabetic retinopathy. Patients with diabetic retinopathy included 40(43%) housewives and 22(23.7%) non-governmental employees, and patients without diabetic retinopathy included 59(59%) housewives and 27(27%) non-governmental employees. The mean diabetes duration was 13.68±6.53 years for with diabetic retinopathy group and 15.7±5.52 years in without diabetic retinopathy group. There were 15(16.1%) cases with diabetic retinopathy on insulin in comparison to 20(20%) cases without diabetic retinopathy. As shown in Table-1.

Table 1: Distribution studied participants according to socio-demographic and disease characteristics

Variables		With diabetic retinopathy No. (%)	Without diabetic retinopathy No. (%)
Age (mean± SD)		55.6±5.87	54.33±6.82
Sex	Male	49(52.7)	38(38)
	Female	44(47.3)	62(62)
Residence	Rural	5(5.4)	9(9)
	Urban	88(94.6)	91(91)
Education	Illiterate	18(19.4)	29(29)
	Primary	52(55.9)	30(30)
	Secondary	13(14)	27(27)
	University	10(10.8)	14(14)
Occupation	Government employee	18(19.4)	12(12)
	Non-government employee	22(23.7)	27(27)
	Retired	13(14)	2(2)
	Housewife	40(43)	59(59)
Duration of disease (mean± SD)		13.68±6.53	15.7±5.52
Medication	Insulin	15(16.1)	20(20)
	Oral	78(83.9)	80(80)

There were 64(68.8%) cases with NPDR and 29(31.2%) with PDR, as shown in Figure-1.

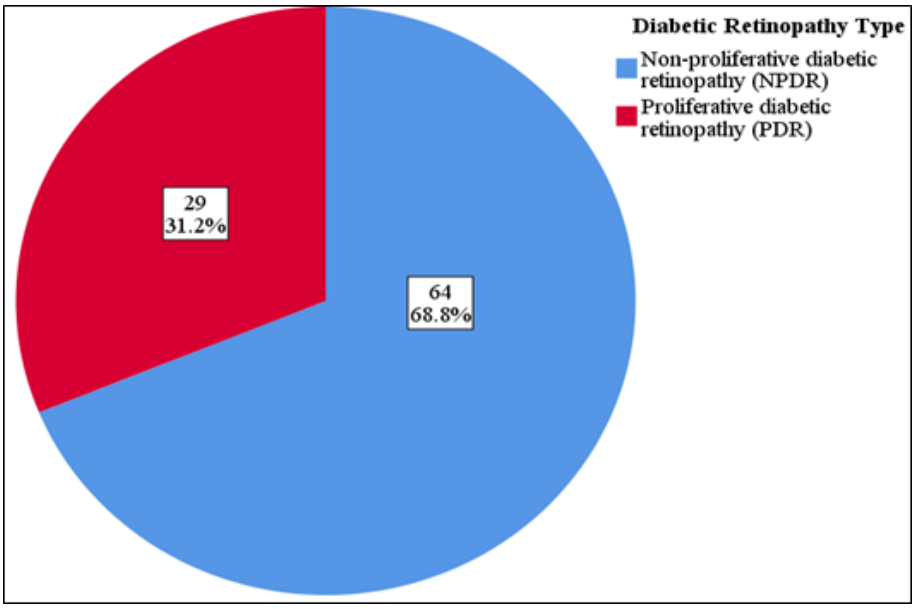

Fig1: Distribution of patients according to type of diabetic retinopathy

S There were 27(29%) patients with diabetic retinopathy who had low S.Mg in comparison to 16(16%) patients without diabetic retinopathy also with low S.Mg, which showed statistically significant association (p=0.030), as shown in Table-2.

Table 2: Distribution of studied group according to carboxylated hemoglobin and serum magnesium levels

Variables		With diabetic retinopathy	Without diabetic retinopathy	Total	P-value
		No. (%)	No. (%)	No. (%)	
HbA1c	Controlled	10(10.8)	20(20)	30(15.5)	0.076
	Uncontrolled	83(89.2)	80(80)	163(84.5)	
S. Mg	Low	27(29)	16(16)	43(22.3)	0.030
	Normal	66(71)	84(84)	150(77.7)	

There was no statistically significant association between HbA1c and NPDR, as there were 7 (10.9%) patients with NPDR with adequate control in comparison to 20(20%) patients without diabetic retinopathy. There was a statistically significant association between NPDR and low S.Mg, as there were 21(32.8%) patients with NPDR and low S.Mg in comparison to 16(16%) in those without diabetic retinopathy. As shown in Table-3.

Table 3: Distribution of NPDR cases according to carboxylated hemoglobin and serum magnesium levels

Variables		NPDR	Without diabetic retinopathy	Total	P-value
		No. (%)	No. (%)	No. (%)	
HbA1c	Controlled	7(10.9)	20(20)	27(16.5)	0.127
	Uncontrolled	57(89.1)	80(80)	137(83.5)	
S. Mg	Low	21(32.8)	16(16)	37(22.6)	0.012
	Normal	43(67.2)	84(84)	127(77.4)	

There was no statistically significant association between HbA1c and PDR, as there were 3 (10.3%) patients with PDR and adequate control in comparison to 20(20%) patients without diabetic retinopathy. There was a statistically significant association between PDR and low S.Mg, as there were 10(34%) patients with PDR and low S.Mg in comparison to 16(16%) in those without diabetic retinopathy. As shown in Table-4. S.Mg was decreased in both NPDR and PDR patients, with no significant difference between the two of them (P-value 0.05).

Table 4: Distribution of PDR cases according to carboxylated hemoglobin and serum magnesium levels

Variables		PDR	Without diabetic retinopathy	Total	P-value
		No. (%)	No. (%)	No. (%)	
HbA1c	Controlled	3(10.3)	20(20)	23(17.8)	0.127
	Uncontrolled	26(89.7)	80(80)	106(82.2)	
S. Mg	Low	10(34.5)	16(16)	26(20.2)	0.029
	Normal	19(65.5)	84(84)	103(79.8)	

There was no statistically significant difference between S.Mg and durations of diabetes among patients with diabetic retinopathy and without diabetic retinopathy, as shown in Table-5.

Table 5: Distribution of duration of diabetes according to S.Mg levels and diabetic retinopathy

Duration of diabetes		With diabetic retinopathy	Without diabetic retinopathy
		Mean± SD	Mean± SD
S. Mg	Low	14.77± 5.8	16.10± 5.4
	Normal	13.13± 6.9	13.63± 5.6
P-value		0.254	0.101

Discussion

Magnesium has a pivotal role in several physiological processes, like vascular tone and calcification, oxidative stress, and regulation of the immune response, all of which are significant factors in the development and progression of diabetic retinopathy [13].

In the current study, patients with diabetic retinopathy showed lower S.Mg in comparison to diabetic patients without diabetic retinopathy, with no significant association between NPDR and PDR patients. These results were in comparison to the results of Shivakumar *et al*. (2021), who reported that S.Mg levels were lower in patients with diabetic retinopathy, however they also reported that S.Mg was lower in patients with more severe diabetic retinopathy [14]. In another study done by Moradiya and Muley (2021), hypomagnesemia was significantly associated with diabetic retinopathy (odds ratio= 4.871) [15]. In another study done by Xing *et al*. (2021), they studied more than two thousand patients with T2DM and reported that lower serum magnesium levels were associated with an increased risk of developing diabetic retinopathy [17]. In addition, Hussain *et al*. (2020) reported that diabetic patients with retinopathy had lower S.Mg levels in comparison to patients without retinopathy [18]. Anveetha and Chittimoju (2021) reported, unlike the current study, that HbA1C along with S.Mg were impaired in patients with diabetic retinopathy in comparison to diabetics without retinopathy [18]. This might be explained by several potential mechanisms; Mg deficiency lowers the activity of antioxidant enzymes like glutathione, thus the oxidative damage to retinal cells would increase, lower Mg levels promote the production of pro-inflammatory cytokines aggravating retinal damage, Mg is crucial for endothelial cell tight junctions function and vascular smooth muscle tone, lower Mg levels contribute to microaneurysms, hemorrhages and impair vasodilation increasing risk for microvascular damage in the retina in diabetic retinopathy [7].

In the current study, low S.Mg was not associated with disease duration. This in agreement with a study by Arpaci *et al*. (2015), who reported that S.Mg showed no statistically significant difference among diabetic patients with and without diabetic retinopathy, disease duration did not affect the S.Mg levels [19]. While in another study by Paladiya *et al*. (2021), both severity and duration of diabetes more than 10 years were significantly associated with hypomagnesemia [20]. The contradictory results might be explained by the complex and multifactorial relationship between S.Mg and diabetes mellitus, as diabetic nephropathy significantly associated with hypomagnesemia and those with nephropathy suffer from progressive urinary loss of magnesium [21]. In addition, personal variances in dietary magnesium intake and supplementation could mitigate magnesium depletion in diabetic patients even with longer duration of the disease.

Dietary patterns play a significant role in regulating magnesium levels, and different dietary factors and patterns impact magnesium levels in diabetic patients. Western diet constitutes low Mg as it is characterized by high quantity of processed foods, refined grains, saturated fats, and sugars, while maintaining low quantities of whole grains, fruits, and vegetables [22], however, mediterranean diet has more Mg than the western one, as it is rich in whole grains, olive oil, nuts, seeds, legumes, fish, and vegetables; low in processed foods [23], and in Iraq, the experts consensus held in 2020 recommended this type of diet in patients with type 2 DM for its better profile in glucose metabolism [24], in addition, high sodium diet increases urinary magnesium excretion [25].

Conclusion

Lower serum magnesium levels are more common in patients with diabetic retinopathy compared to those without, regardless of the severity of the condition. This study didn't observe a strong link between magnesium levels and factors like HbA1c or diabetes duration.

References

1. Li B, Cheng X, Huang Y, Zhou C, Gu C, Zhu X, *et al*. The differences of metabolic profiles, socioeconomic status and diabetic retinopathy in US working-age and elderly adults with diabetes: results from NHANES 1999–2018. Acta Diabetologica, 2024, 1-10.
2. Retinal Vascular Disease. In: Salmon JF, editor. Kanski's Clinical Ophthalmology E-Book: A Systematic Approach: Elsevier, 2024, 506-23.
3. Schwalfenberg GK, Genuis SJ. The importance of magnesium in clinical healthcare. Scientifica,2017:(1):4179326.
4. Freedman MR, Keast DR. White potatoes, including french fries, contribute shortfall nutrients to children's and adolescents' diets. Nutrition research,2011:31(4):270-7.
5. Nielsen FH. Magnesium deficiency and increased inflammation: current perspectives. Journal of inflammation research,2018:11:25-34.
6. Oost LJ, Tack CJ, de Baaij JHF. Hypomagnesemia and Cardiovascular Risk in Type 2 Diabetes. Endocrine Reviews,2022:44(3):357-78. doi:10.1210/endrev/bnac028.
7. Barbagallo M, Dominguez LJ. Magnesium and type 2 diabetes. World J Diabetes,2015:6(10):1152-7, doi:10.4239/wjd.v6.i10.1152.
8. Barbagallo M, Di Bella G, Brucato V, D'Angelo D, Damiani P, Monteverde A, *et al*. Serum ionized magnesium in diabetic older persons. Metabolism,2014:63(4):502-9.
9. Kostov K. Effects of magnesium deficiency on mechanisms of insulin resistance in type 2 diabetes: focusing on the processes of insulin secretion and signaling. International journal of molecular sciences,2019:20(6):1351.
10. Ham JY, Jang YK, Jeon BY, Shon YH. Magnesium from Deep Seawater as a Potentially Effective Natural

Product against Insulin Resistance: A Randomized Trial. Medicina,2024:60(8):1265. doi:10.3390/medicina60081265.
11. Sherwani SI, Khan HA, Ekhzaimy A, Masood A, Sakharkar MK. Significance of HbA1c Test in Diagnosis and Prognosis of Diabetic Patients. Biomarker Insights,2016:11:BMI.S38440, doi:10.4137/BMI.S38440.
12. Al Alawi AM, Majoni SW, Falhammar H. Magnesium and Human Health: Perspectives and Research Directions. International Journal of Endocrinology,2018:(1):9041694. doi:https://doi.org/10.1155/2018/9041694.
13. Mamilla M, Yartha SGR, Tuli R, Konipineni S, Rayaprolu DT, Borgharkar G, *et al*. Role of Magnesium in Diabetic Nephropathy for Better Outcomes. Cureus,2023:15(8):43076. doi:10.7759/cureus.43076.
14. Shivakumar K, Rajalakshmi AR, Jha KN, Nagarajan S, Srinivasan AR, Lokesh Maran A. Serum magnesium in diabetic retinopathy: the association needs investigation. Ther Adv Ophthalmol, 2021, 13:25158414211056385. doi:10.1177/25158414211056385.
15. Moradiya K, Muley A. A study of serum magnesium level in type 2 diabetes mellitus and its association with glycemic control and its complications. International Journal of Noncommunicable Diseases,2021:6(1):34-7. doi:10.4103/jncd.jncd_53_20.
16. Xing B, Xu X, Li C, Zhao Y, Wang Y, Zhao W. Reduced Serum Magnesium Levels Are Associated with the Occurrence of Retinopathy in Patients with Type 2 Diabetes Mellitus: a Retrospective Study. Biological Trace Element Research,2021:200:2025-32. doi:10.1007/s12011-021-02824-w.
17. Hussain S, Reza S, Raza H, Zafar S, Ahmad S, Javed RA. Study of Serum Magnesium levels in diabetic patients with and without retinopathy. The professional medical journal,2020:27:2656-61. doi:10.29309/tpmj/2020.27.12.4132.
18. Anveetha P, Chittimoju VK. Study of HbA1c and serum magnesium in diabetic patients with retinopathy,2021:5:1-5. doi:10.33545/26174693.2021.V5.I1A.55.
19. Arpaci D, Tocoglu AG, Ergenc H, Korkmaz S, Ucar A, Tamer A. Associations of serum Magnesium levels with diabetes mellitus and diabetic complications. Hippokratia,2015:19(2):153-7.
20. Paladiya R, Pitliya A, Choudhry AA, Kumar D, Ismail S, Abbas M, *et al*. Association of Low Magnesium Level with Duration and Severity of Type 2 Diabetes. Cureus,2021:13(5):15279. doi:10.7759/cureus.15279.
21. Smithiseth K, Leurcharusmee P, Sawaddiruk P, Chattipakorn N, Chattipakorn S. Unraveling the Link Between Magnesium and Diabetic Neuropathy: Evidence from *in vitro* to Clinical Studies. Nutrition Research, 2025. doi:https://doi.org/10.1016/j.nutres.2025.01.005.
22. Clemente-Suárez VJ, Beltrán-Velasco AI, Redondo-Flórez L, Martín-Rodríguez A, Tornero-Aguilera JF. Global Impacts of Western Diet and Its Effects on Metabolism and Health: A Narrative Review. Nutrients, 2023, 15(12). doi:10.3390/nu15122749.
23. Schwingshackl L, Morze J, Hoffmann G. Mediterranean diet and health status: Active ingredients and pharmacological mechanisms. Br J Pharmacol,2020:177(6):1241-57. doi:10.1111/bph.14778.
24. Abusaib M, Ahmed M, Nwayyir HA, Alidrisi HA, Al-Abbood M, Al-Bayati A, *et al*. Iraqi Experts Consensus on the Management of Type 2 Diabetes/Prediabetes in Adults. Clin Med Insights Endocrinol Diabetes,2020,13:1179551420942232. doi:10.1177/1179551420942232.
25. Lee CT, Lien YH, Lai LW, Ng HY, Chiou TT, Chen HC. Variations of dietary salt and fluid modulate calcium and magnesium transport in the renal distal tubule. Nephron Physiol,2012:122(3-4):19-27. doi:10.1159/000353199.