

RESEARCH ARTICLE

Comparative Study of Serum Magnesium and Phosphate Levels in Type 2 Diabetes Mellitus Patients With and Without Foot Ulcer

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Abstract: *Background:* Diabetic foot ulcer (DFU) is a serious complication of type 2 diabetes mellitus (T2DM). Electrolyte imbalances, particularly hypomagnesemia and hypophosphatemia, may impact insulin sensitivity and wound healing. *Aim:* To compare serum magnesium and phosphate levels in T2DM patients with and without DFU, and to evaluate their relationship with glycemic control and ulcer severity. *Methods:* A hospital-based observational study was conducted in Meerut, India (Sept 2023–Mar 2025). Ninety T2DM patients (45 with DFU and 45 without) were enrolled. Serum magnesium, phosphate, fasting blood glucose, and HbA1c were measured; ulcer severity was graded. Statistical analysis was performed using SYSTAT 13.2; $p < 0.05$ was deemed significant. *Results:* Mean age was 56.3 years; male predominance was noted in DFU group (64.4%). Hypomagnesemia was significantly more common in DFU cases (64.4%) compared to controls (13.3%) ($p < 0.001$). Hypophosphatemia was present in 53.3% of DFU cases versus 4.4% of controls ($p < 0.001$). Mean HbA1c was higher in DFU group (9.17 ± 2.7) than controls (7.3 ± 2.1). *Conclusion:* Hypomagnesemia and hypophosphatemia are significantly associated with DFU in T2DM. Monitoring and correcting these deficiencies may aid in prevention and management of DFU.

Keywords: Type 2 Diabetes Mellitus; Diabetic Foot Ulcer; Serum Magnesium; Serum Phosphate; Glycemic Control

INTRODUCTION

Diabetes mellitus affects approximately 500 million individuals worldwide, with India bearing a significant portion of this burden. Chronic hyperglycemia in type 2 diabetes mellitus (T2DM) leads to multiple microvascular complications, including neuropathy and peripheral arterial disease—key contributors to diabetic foot ulcers (DFUs).[1] DFUs are associated with high morbidity and pose a considerable risk of limb amputation.

Pathophysiology of DFU involves impaired protective sensation, motor dysfunction, skin breakdown from autonomic neuropathy, ischemia due to vascular insufficiency, and compromised immunity. In recent years, the role of micronutrient imbalance—particularly hypomagnesemia and hypophosphatemia—has gained interest. Magnesium is critical for insulin signaling, glucose utilization, and vascular function, and deficiencies are common in poorly controlled diabetes.[2] Hypophosphatemia, impacting ATP production and wound healing, may further exacerbate tissue repair deficits.[3]

While international studies have reported these associations, there is limited data from Indian clinical settings. This study aimed to compare serum magnesium and phosphate levels in T2DM patients

with and without DFU and explore their relationship with glycemic control and ulcer severity.

MATERIAL AND METHODS

Study design and setting: A hospital-based observational analytic study conducted in the Department of General Surgery, Chhatrapati Shivaji Subharti Hospital, Meerut, from September 2023 to March 2025.

Participants: Ninety T2DM patients were enrolled—45 with DFU (cases) and 45 without (controls). T2DM diagnosis conformed to ADA criteria. Ethics approval was obtained; all participants provided informed consent.

Inclusion criteria: Adult T2DM patients with or without DFU.

Exclusion criteria: Patients with chronic kidney disease, sepsis, endocrine disorders, malabsorption, alcoholism, pregnancy, or on medications affecting magnesium levels (e.g., diuretics, PPIs).

Data collection: Demographics, duration of diabetes, and ulcer grading were recorded using the Dysvascular Foot Breakdown classification. Blood samples were collected after overnight fasting.

Laboratory investigations:

- Serum magnesium: Colorimetric method (Roche C-501); reference 1.8–2.6 mg/dl
- Serum phosphate: Reference 2.3–4.7 mg/dl
- HbA1c: HPLC method

- Fasting blood glucose, urea, creatinine: Beckman Coulter Synchron LX20

Statistical Analysis: Data were entered in Excel and analyzed using SYSTAT 13.2. Continuous variables are presented as mean \pm SD; categorical variables as counts and percentages. Group comparisons used Student's *t*-test and chi-square tests. Significance was defined as $p < 0.05$.

RESULTS AND OBSERVATIONS:

Demographics: The mean patient age was 56.3 years (range: 38–83). Age group 51–60 years comprised 44% of the cohort. Male proportion was higher in DFU group (64.4%) than in control group (42.2%).

Serum magnesium: Hypomagnesemia (<1.8 mg/dl) was observed in 29 of 45 DFU cases (64.4%) versus 6 of 45 controls (13.3%) ($p < 0.001$). None of the cases had magnesium above the normal range, while 22 controls did.

Serum phosphate: Hypophosphatemia (<2.3 mg/dl) occurred in 24 of 45 DFU patients (53.3%) and in 2 of 45 controls (4.4%) ($p < 0.001$). Normal phosphate values were seen in 18 cases and 40 controls.

Glycemic Control: The mean HbA1c was significantly higher in DFU patients (9.17 ± 2.7) vs controls (7.3 ± 2.1). Furthermore, 60% of DFU cases had fasting glucose >200 mg/dl, compared to 44% of controls.

Ulcer characteristics: Grade 3 ulcers were most common (36%), followed by Grade 2 (24%) and Grades 4–5 (31%). Most DFU patients (75%) had diabetes duration between 1–10 years.

(Include Table 1: Demographic and metabolic parameters; Table 2: Distribution of hypomagnesemia/hypophosphatemia; Figure 1: Comparison of HbA1c values)

DISCUSSION

Our study reveals a significant association between low serum magnesium and phosphate levels and the presence of DFU in T2DM patients. The prevalence of hypomagnesemia in DFU cases (64.4%) versus controls (13.3%) aligns with findings by Rodríguez-Morán and Guerrero-Romero, and Keşkek et al., which linked low magnesium with ulcer risk.[4,5] Magnesium is vital in maintaining insulin sensitivity and vascular health; its deficiency obstructs wound healing and endothelial function.

Hypophosphatemia in over half of the DFU group suggests phosphate's role in tissue repair, ATP metabolism, and vascular integrity. Though less studied, Ugwuja et al. reported similar trends in poorly controlled diabetics.[6]

Elevated HbA1c levels in DFU patients underscore the interplay of poor glycemic control with electrolyte disturbances in ulcer pathogenesis. Male predominance in DFU cases may reflect risk behavior, barefoot exposure, and trauma, particularly in the Indian context. Strengths of this study include its focused design and simultaneous evaluation of both minerals. However, limitations encompass moderate sample size, lack of dietary assessment, and regional single-center scope. Clinical implications: Routine serum magnesium and phosphate screening in diabetic patients could aid early identification of those at high risk for DFU. Future interventional trials could explore the efficacy of supplementation in ulcer prevention and healing.

CONCLUSION

Hypomagnesemia and hypophosphatemia are significantly associated with diabetic foot ulcers in patients with T2DM. These electrolyte deficiencies may

exacerbate poor glycemic control and impair vascular and cellular repair mechanisms leading to ulceration. Incorporating evaluation of serum magnesium and phosphate in diabetic care protocols may enhance risk stratification and preventive strategies against DFU. Larger, multicenter and interventional studies are warranted to establish supplementation as a component of DFU management.

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