
| RESEARCH ARTICLE**Prevalence of Peripheral Vascular Calcification in Chronically Kidney-Diseased Patients on Regular Hemodialysis Using Plain X-Ray Method****Ali Yasir Ali¹ ✉ and Huda Khalaf Jawad**¹*Department of Medicine, Al-Krama Teaching Hospital, Wasit, Iraq*²*Public Health Laboratory, Wasit Health Directorate, Wasit, Iraq***Corresponding Author:** Ali Yasir Ali, **E-mail:** aliyassirali83@gmail.com

| ABSTRACT

Cardiovascular disease (CVD) represents one of the most common causes of death on dialysis patients, which increasingly accepted as a part of excess vascular calcification that highly prevalent in patients maintained on chronic hemodialysis. This study aims to assess the prevalence of vascular calcifications among patients undergoing hemodialysis in Iraqi Center of Dialysis in Baghdad teaching hospital, and to identify the associated risk factors. A total of 94 end stage renal disease patients on regular hemodialysis from July (2024) to January 2025 were enrolled, and subjected to estimation the prevalence of vascular calcifications among those patients using Adragao score where plain X-ray of the hands and pelvis were used. Additionally, patient's characteristics and possible risk factors were compared. The findings revealed that there were 60.42% (58/94) men and 39.58% (36/94) women were undergoing dialysis. The median age of the study population was 52 years (ranged from 44 to 60 years) and a median duration of dialysis of 24 months (ranged from 6 to 60 months). The majority of study patients were diabetic (82.98%) and 71.27% were diagnosed with a hypertension; while, 39.36% were having vascular calcification (Adragao score >3). Statistically, duration of dialysis (p value = 0.022), diabetes (p value = 0.015), calcium phosphate product (p value = 0.025), and serum phosphate (p value = 0.044) were associated with vascular calcifications. No significant association was found between vascular calcifications and age, gender, hypertension, corrected calcium level. In conclusion, vascular calcifications are moderately prevalent among patients undergoing hemodialysis at this center, and were found to be correlated with diabetes, duration of dialysis, calcium phosphate product, and phosphate. A larger, multicenter, prospective study need to be conducted at national level, in order to confirm the findings of this study and to identify further modifiable risk factors.

| KEYWORDS

Chronic kidney disease, hemodialysis, vascular calcification, Adragao score.

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1. Introduction

Chronic kidney disease (CKD) is defined as kidney damage or glomerular filtration rate (GFR) below 60ml/min per 1.73m² for 3 months or more irrespective of the cause, which classified into five stages to simplify the categorization of CKD (Młynarska et al., 2024; Neuen et al., 2026). The true incidence and prevalence of CKD within a community are difficult to ascertain as early to moderate CKD is usually asymptomatic (Selby and Taal, 2024). However, various epidemiologic studies attempted to clarify that issue and have made relatively similar observations suggesting a prevalence of CKD of around 10%, albuminuria of around 7%, and GFR below 60 ml/min per 1.73m² of around 3%

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(Filler et al., 2024; Francis et al., 2024). The natural history of CKD stages remain to be fully defined as it has generally been assumed that the majority of patients with CKD stages 3B to 5 progresses relentlessly to ESRD (Romagnani et al., 2025). This has recently been challenged as progression is variable, and a sizable percentage of these patients have stable kidney function or die prematurely of cardiovascular disease (Zoccali et al., 2023). A Canadian study showed the natural history of CKD stages 3 and 4 to be variable and reflecting the patient's risk factor profile (Beberashvili et al., 2025). A straight-line relationship is often found between the reciprocal of serum creatinine values or the estimated GFR and time. However, a significant percentage of patients do not progress in a predictable linear fashion and have breakpoints in their progression slopes, suggesting acceleration or slowing down of the rate of progression of CKD (Chu et al., 2023; Larsen et al., 2023; Komici et al., 2026). These breakpoints could be either spontaneous or secondary to events such as infections, dehydration, changes in the adequacy of systemic blood pressure control, and exposure to nephrotoxins, in particular non-steroidal anti-inflammatory drugs (NSAIDs) or radio contrast agents (Lu et al., 2025; Yang et al., 2025; Zhao et al., 2026). Attention has also been drawn recently to the impact of intercurrent acute kidney injury (AKI) events on the rate of progression of CKD. It is also important to appreciate that some patients with mild to moderate CKD have stable renal function for sustained periods (Missikpode et al., 2023).

For diagnosis, several imaging techniques have been described in the literatures as possible screening tools for vascular calcification. The simplest technique is plain radiography, with the salient features being pipe-stem calcification of the tunica media and internal elastic lamina (Izzo et al., 2024). Although some degree of differentiation between intimal and medial calcification may be inferred from the use of plain films, using any of the plain X-ray methods is inexpensive, easy to interpret, and useful in terms of cardiovascular risk stratification as well as therapeutic guidance (Huang et al., 2026). Different X-ray method scan be used to identify vascular calcification in dialysis patients: plain X-ray of hand and pelvis (Adragao score), the abdominal aorta, or the vascular access (Disthabanchong and Boongird, 2017). Vascular calcification score was evaluated in plain radiographic films of pelvis and hands. The pelvis radiographic films were divided into four sections by two imaginary lines: a horizontal line over the upper limit of both femoral heads and a median vertical line over the vertebral column (Yeap and Budak, 2021; Žuža et al., 2022). The films of the hands were divided, for each hand, by a horizontal line over the upper limit of the metacarpal bone (Foley et al., 2021). Electron beam computed tomography (EBCT) or multislice computed tomography (CT) of coronaries is considered the gold standard for quantitative evaluation of vascular calcification, it is very expensive, not widely available, and is nonspecific in dialysis patients (Zhang et al., 2021; Hutcheson and Goettsch, 2023). It does not distinguish between intimal and medial wall calcification though the coronary artery calcification using special scanners and software has been the most widely studied (Onnis et al., 2024). A paucity of data exists concerning the using of EBCT or CT in patients with renal disease, which have largely been performed during the period of widespread use of calcium-containing phosphate binders (Chen et al., 2025). Ultrasonography of the large arteries and echocardiography to assess for the presence of valvular calcifications: Vascular ultrasound can frequently show calcified plaques and calcified media, although intravascular ultrasound and optical coherence tomography offer further refinements in sensitivity (Sarwar et al., 2024). Ultrasonic / echocardiographic signal backscatter analysis, energy subtraction radiography, and nuclear medicine bone tracer techniques can show the presence of calcium, at microscopic level, but these techniques do not differentiate between its presence in vessels or interstitium (Fontes-Pereira et al., 2018; Muller et al., 2023). Hence, the current study aims to assess the prevalence of vascular calcifications among patients undergoing hemodialysis in Iraqi Center of Dialysis in Baghdad teaching hospital, and to identify the associated risk factors.

2. Materials and methods

2.1 Samples and data

A total of 94 ESRD patients on regular HD were selected to be enrolled in this study. Informed consent was obtained from all participants and this study was approved by the ethical committee of Baghdad University, College of Medicine –Medical Department. The inclusion criteria was include the patients with chronic renal failure on regular hemodialysis two sessions a week three to four hours for each sessions for at least six months , regardless the age and gender were eligible. While, the exclusions criteria was involved exception of patient with a history of

cardio vascular diseases (IHD, CVA, PAD), refused to participate, limb amputation, malignancy at time of study, and acute illness at time of study. Data were collected by taking detailed history and thorough physical examination had been performed for each patient. Data from patients include the age, gender and etiology of ESRD medical history of chronic illness (diabetes mellitus, hypertension) duration of hemodialysis, when patients agreed to participate a venous blood sample was drawn and sent for laboratory, investigations done included total serum calcium, serum phosphorus, blood urea, serum creatinine, and albumin.

2.2 Laboratory measurement

These investigations were done in laboratory unit in Iraqi center of dialysis in Baghdad Teaching Hospital. The device used for analysis of blood samples spectrophotometer 7200, the reference values were the following: blood urea at 20-45mg/dl, serum creatinine at 0.7-1.4mg/dl, total serum calcium at 8.5-10.5mg/dl, serum phosphate at 2.5-4.5 mg/dl, and albumin at 3.5-5.5gm/dl. Corrected calcium calculated by adding 0.8 mg/dl to serum calcium for each 1gm/dl reduction in albumin level below 4.1gm/dl.

2.3 Radiology

The patient were sent to radiology department in same hospital to assess peripheral vascular calcification using Adragao score, where patients obtain two plain x-ray films, one for both hands, and other for pelvis. The pelvis radiographic films were divided into four sections by two imaginary lines: a horizontal line over the upper limit of both femoral heads and a median vertical line over the vertebral column. The films of the hands were divided, for each hand, by a horizontal line over the upper limit of the metacarpal bones. The presence of linear calcifications in each section was counted as 1 and its absence as 0. The final score was the sum of all sections ranging from 0 to 8. Vascular calcifications were deliberately evaluated only in muscular arteries: iliac, femoral, radial and digital. Pelvis films evaluated iliac and femoral arteries; hand films evaluate radial and digital arteries. The analysis of all the radiographic films was performed by one single experienced radiologist blinded to patient information. Only linear calcifications, with or without patchy calcifications, were considered for the final calcification score, because they outline the vessel wall and have undoubtedly vascular localization. Patchy isolated calcifications that may be associated with intimal calcification were not considered in this score because they may be confused with other types of extra-vascular calcifications, for instance, phlebitis. Then patients divided according to Adragao score in to two groups: those with score less than or equal three and those with more than three.

2.4 Statistical analysis

All continuous data were presented as mean $\pm$ standard deviation, while discrete variables presented using percentage and number of patients. For continuous data t-test performed to assess the statistical difference, while for discrete variable chi square method were performed; for 2x2 tables Fischer's exact test performed. To assess the degree of correlation between Adragao score and different continuous variable person correlation were performed and scatterplot diagramed were drawn. Statistical significance were consider at level of significance less than 0.05.

3. Results

Data from medical records of 94 subjects undergoing dialyses [58 men (60.42%) and 36 women (39.58%)] were retrieved. The median age of the study population was 52 years [44 -60] and a median duration of dialysis of 24 months [6-60] months. Table (1) shows that 60.42% of patients were males, the majority of were undergo diabetes mellitus (DM), (82.98%), also 71.27% of patients were hypertensive. About 39.36% of patient had vascular calcification (Adragao score >3). Duration of dialysis, which follows normal distribution so mean and stranded deviation, was used to present data; mean of 27 ± 14.65 months ranging from 6-60 months.

Table (1): Demographic characteristics of the study patients

Variable	No.	Percentage
Age (Year), M $\pm$ SD	50.48 $\pm$ 12.9	
Hypertension	67	71.27%
Male	58	60.42%
Female	36	39.58%
Diabetes mellitus	78	82.98%
Adragao score > 3	37	39.36%
Duration of HD (month)	27 $\pm$ 14.65	
Range (months)=	6 – 60	

Table (2): Biochemical parameters of the study patients

Variable	Value (M $\pm$ SD)
Blood urea (mg/dl)	114.58 $\pm$ 41.26
Serum creatinine (mg/dl)	5 $\pm$ 3.23*
Serum Calcium corrected (mg/dl)	8.873 $\pm$ 1.097
Serum albumin (gm/dl)	3.33 $\pm$ 0.62
Calcium phosphate product	37.12 $\pm$ 14.72
* Median $\pm$ Interquartile range	

Table (3): Comparisons between different variables using Adragao score

Variable	Adragao score		P value
	≤ 3	> 3	
Age	49.1 $\pm$ 14.3	52.7 $\pm$ 10.3	0.362
Duration of HD (months) [#]	22.3 $\pm$ 13.3	34.3 $\pm$ 14	0.006
Blood urea (mg/dl) [#]	117.7 $\pm$ 40.4	109.7 $\pm$ 43.3	0.528
Serum creatinine (mg/dl)*	5.3 $\pm$ 3.83	5 $\pm$ 1.775	0.693
Serum albumin (gm/dl) [#]	3.343 $\pm$ 0.636	3.306 $\pm$ 0.602	0.844
Serum Ca corrected (mg/dl) [#]	8.983 $\pm$ 0.992	8.7 $\pm$ 1.26	0.404
Calcium phosphate product [#]	33.9 $\pm$ 12.4	42.1 $\pm$ 16.9	0.064
[#] Mean $\pm$ standard deviation used to present data			
* Mann Whitney nonparametric test to assess significance for Median of data			

Table (4): distribution of variables using Adragao score

Variables		Adragao score				P value
		≤3		>3		
		No	%	No	%	
Gender	Male (n=58)	39	67.86	19	32.13	0.354*
	Female (n=36)	18	50	18	50	
Hypertension	Positive (n=68)	45	66.67	23	33.33	0.315*
	Negative (n=26)	12	46.15	14	53.85	
DM	positive(n=78)	37	47.43	41	52.56	0.015*
	negative (n=16)	13	81.25	3	18.75	
Duration of dialysis (months)	≤12(n=20)	18	90	2	10	0.022
	> 12 – 24 (n=33)	23	69.7	10	30.3	
	> 24 (n=41)	16	39	25	61	
Age group	< 40	12	75	4	25	0.183
	40 – 49	10	71.43	4	28.5	
	50 – 59	16	42.11	23	57.89	
	≥ 60	19	75	6	25	

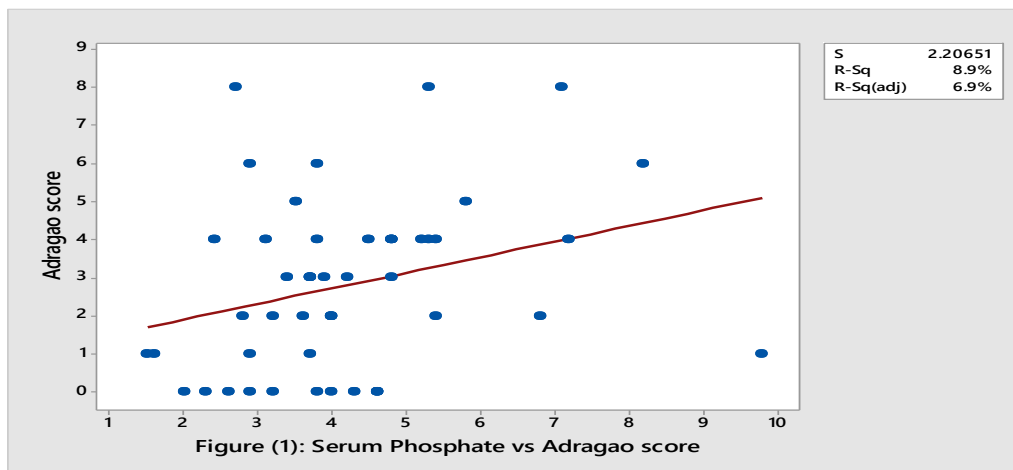
* Fisher's exact test for 2x2 tables was used to assess the statistical significance

As we notice from both table (4) and (5) all the variable did not differ statistically when we divide them using Adragao score (less than or equal to 3, and more than 3) except for the duration of hemodialysis and diabetes mellitus.

Table (5): correlation between Adragao score and different variables

Variable	P value	Correlation coefficient
Calcium phosphate product	0.025	0.329
Age	0.647	0.069
Serum creatinine	0.885	0.022
Blood urea	0.725	-0.053
Duration of HD	0.002	0.441
Serum phosphate	0.044	0.299
Serum calcium corrected	0.886	-0.022

Table (6) shows correlation between Adragao score and different variables and shows that serum phosphate, calcium phosphate product, and duration of haemodialysis correlate with Adragao score, while serum creatinine, blood urea, serum calcium corrected did not correlate with it. Calcium and phosphate product correlate better with Adragao score than serum phosphate alone. Duration of HD was positively correlated with Adragao score (Figures 1-3).



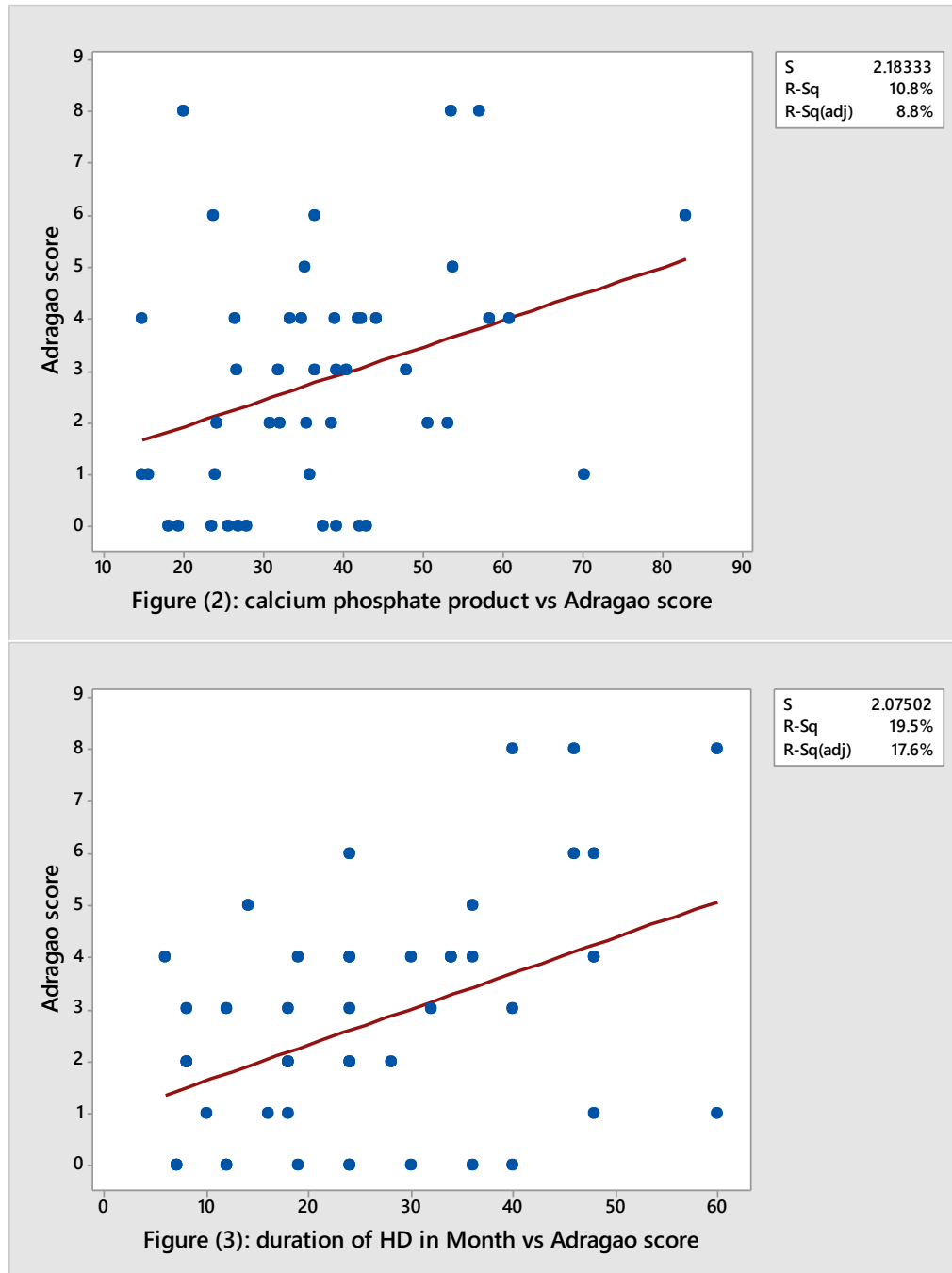


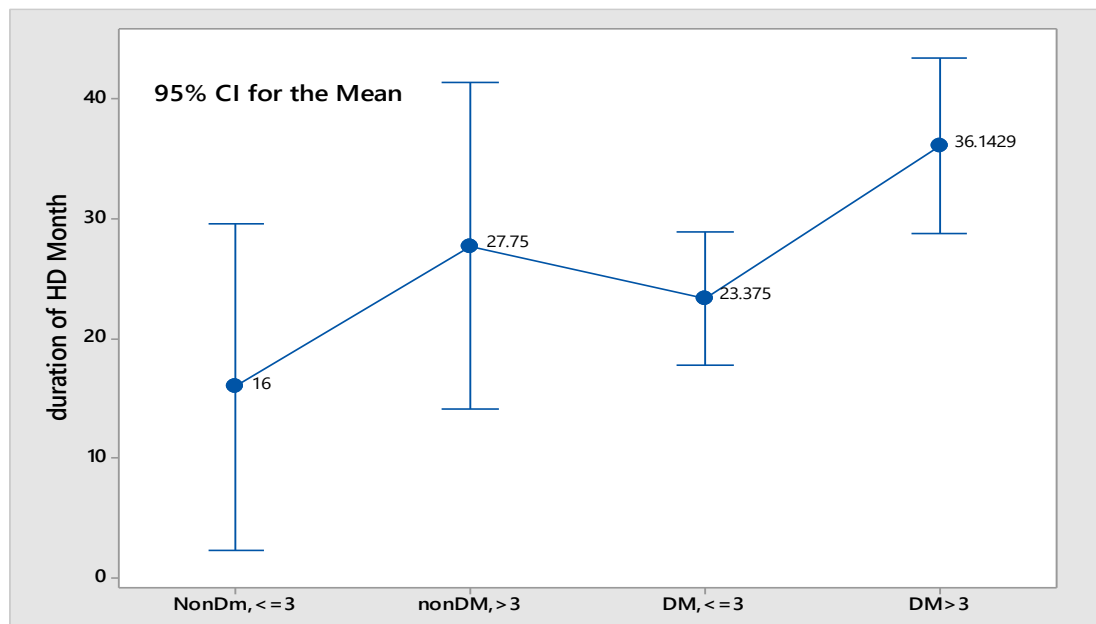
Table (7): Multiple linear correlation between different variables and Adragao score

Variable	Standardized correlation coefficient (beta)	P value	Partial correlation coefficient
Duration of dialysis	0.422	0.002	0.446
Serum phosphate	-0.082	0.829	-0.034
Calcium phosphate product	0.379	0.319	0.154

Table (8): Duration of dialysis, diabetic status and vascular calcification

Variable	>3		≤3		P value
Duration of dialysis	DM	Non DM	DM	Non DM	
Percentage	22.2	77.8	14.3	85.7	
M±SD	36.14±13.64	27.75±15.06	23.38±13.45	16±11.86	0.021

Table (7) and (8) shows that there were statically significant differences when comparing the duration of dialysis in patient considering DM and vascular calcification (Adragao score as index of calcification) with p value = 0.021. In post hoc analysis of the individual group (Tukey honesty test) found that patients with DM when compared using Adragao score that duration of dialysis in >3 group (36.14 months) was statically significant when compared to DM with ≤ 3 group (23.38 months) p value 0.037 (Figure.4).

**Figure (4): interval plot of duration of dialysis (months) using diabetic and Adragao score as parameters**

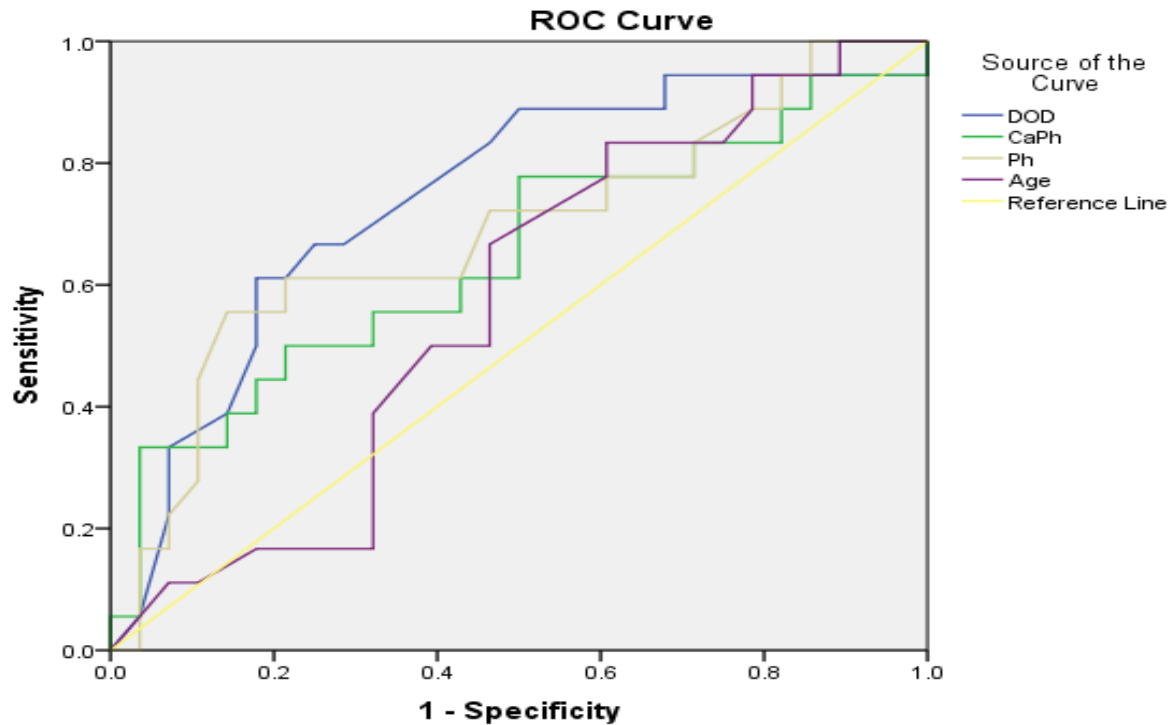
3.1 ROC curve

To show which of continues variables (age, phosphate, calcium phosphate product, and duration of dialysis) predict vascular calcification (vascular calcification predicted by Adragao score more than 3).

Table (9): ROC curve analysis

Test Result Variable(s)	AUC	Asymptotic 95%CI		P value
		Lower Bound	Upper Bound	
Duration of haemodialysis (months)	0.743	0.592	0.894	0.006
Calcium Phosphate product	0.647	0.476	0.818	0.096
Phosphate	0.684	0.519	0.848	0.037
Age (years)	.570	.403	.738	.424

As shown duration of dialysis was the most important predictor for vascular calcification with fair predictability (AUC = 0.743); in which 29 months was considered as cut off above which there is a vascular calcification. Phosphate also shown predictability for vascular calcification, but it was poor (AUC = 0.684). Age and calcium phosphate product did not predict vascular calcification (p value: 0.424 and 0.096 respectively).



Diagonal segments are produced by ties.

Figure (5): ROC curve analysis

4. Discussion

In this study we found that 39.36% of the population undergoing hemodialysis at this tertiary center developed peripheral vascular calcifications after a median duration of 24 (95%CI 18.917-32.165) months; (27 ± 14.65) months. Patients who developed vascular calcification were hypertensive 78.57%. Dialysis duration was the only independent predictors of vascular calcifications. A recent study reported that half of their patients on hemodialysis were having vascular calcification (Bai et al., 2022). This expected vascular calcifications to be highly prevalent in those patients, even higher than those reported in the literature because of the high prevalence of diabetes and the high use of calcemic containing phosphate binders and this was not true for our prediction (Cozzolino et al., 2019; Singh et al., 2021). Some studies in dialysis patients have demonstrated that vascular calcifications may progress or remain stable depending on the control of mineral metabolism alterations and that phosphate binder choice may have an impact on mortality (Reiss et al., 2018; Viegas et al., 2019; Musawi et al., 2026). Pereira and Frazão (2020) showed an association between vascular calcifications and low bone turnover and found a significant interaction between calcium-containing phosphate binders and aortic calcifications and stiffness in the presence of adynamic bone disease. However, only peripheral vascular calcifications were assessed in the current study using a plain X-ray film, which obviously has lower sensitivity than other methods in detecting vascular calcification in addition to the role of small sample size (Yang et al., 2023; Ding et al., 2026).

Diabetes has been emphasized to be a strong risk factor for atherosclerotic cardiovascular disease, cardiac calcification, and peripheral vascular disease in chronic hemodialysis patients (Kobayashi, 2017; Al-Hetty et al., 2023; Siracusa et al., 2024). This was consistence with these findings, where diabetes seems to be a risk for the development of peripheral vascular calcifications. In this study patient with vascular calcification and DM were having longer duration of dialysis compared with patients having no vascular calcification whether they had DM or not, this indicates a possible role of DM and dialysis duration as a cause of vascular calcification, this relation was statistically significant (Ramirez-Sandoval et al., 2016; AL-Shaeli et al., 2022; Xiong et al., 2022).

In a number of studies, the findings demonstrated that only diabetes and duration of dialysis were independent predictors of the development of vascular calcification (Niu et al., 2019; Li et al., 2024; Xiong et al., 2025). Also, patients with vascular calcification were maintained on dialysis for a longer duration than those who did not have vascular calcification, and they found that diabetic subjects developed vascular calcification at almost half duration compared to non-diabetics (Chen et al., 2017; Zhang et al., 2023). These findings were similar to results of many studies which have demonstrated a strong association between diabetes and the development of vascular calcification with more than four-fold increased risk (Bartoli-Leonard et al., 2019; Dube et al., 2021; Razavi et al., 2022). Diabetes-related vascular calcifications are known to occur long before the initiation of dialysis; which could be attributed to the fact that diabetes is involved in both types of vascular calcification but mainly medial calcifications which tend to be rapidly progressive (Lanzer et al., 2021; Li et al., 2024; Costea et al., 2025).

Current study seemed that hypertension was not associated with increased risk of vascular calcification development, in contrary to other studies showed that hypertension was strongly associated with the development of vascular calcification as they found all patients who developed vascular calcification were hypertensive and systolic blood pressure was higher in subjects with vascular calcification compared to the other group, while it shown hypertension to be independent predictor of severe vascular calcification (Ge et al., 2017; Durham et al., 2018; Chen et al., 2020; Chao et al., 2025). All these indicate the importance of hypertension as a cause of and acceleration of vascular calcification; in contrary to this study in which we depend on history of hypertension not reliable measurement of systolic and diastolic blood pressure to see it magnitude.

To evaluate disturbance of bone mineral metabolism in end-stage renal disease, we studied the relation of serum calcium, phosphate, calcium phosphate product with vascular calcification and we found only calcium phosphate product and phosphate associated with development of vascular calcification (p value 0.025 and 0.044 respectively). These findings were in agreement with that recorded by other researchers (Cuzzolino et al., 2019; Salam et al., 2021; Lv et al., 2022). Another study showed that disturbed bone mineral metabolism in end-stage renal disease was a strong predictor of vascular calcifications (Izzo et al., 2024). In this respect, risk factors described include hyperphosphatemia, secondary hyperparathyroidism, and use of calcium-based phosphate binders (Bover et al., 2016). Several studies identified that no remarkable association was found between vascular calcification and any of these variables (Kim and Hwang, 2021; Siracusa et al., 2024; González-García et al., 2026). Although the levels of serum phosphorus and serum parathyroid hormone were higher among the group with vascular calcifications, the difference did not reach statistical significance as detected by Nematollahi et al. (2017). This study showed that duration of dialysis is the most important predictor for vascular calcification, also it shows a strong correlation with Adragao score, and it was independently correlated with Adragao score. This consistence with other studies that shown the duration of dialysis being persistently described as an independent risk factor for the development of vascular calcifications in several studies (Dai et al., 2020; Bellasi et al., 2021; Zhang et al., 2023).

5. Conclusions

Vascular calcifications are moderately prevalent among patients undergoing hemodialysis at this center, and were found to be correlated with diabetes, duration of dialysis, calcium phosphate product, and phosphate. However, this study emphasized that larger, multicenter, prospective study need to be conducted at national level, in order to confirm the findings of this study and to identify further modifiable risk factors, to decrease the incidence of vascular calcifications and the incurring cardiovascular morbidity and mortality in our population with the avoidance of marked or prolonged positive calcium balance. This includes the more successful calibration of vitamin D administration and avoidance of high doses of calcium-based phosphate binder. Much greater attention should be made to the successful manipulation of plasma phosphate levels by better dialysis techniques and better patient education relating to diet and phosphate-binders.

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