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Studying Sclerostin in Hemodialysis and after Kidney Transplantation in Egyptian Populations and Its Relation to Vascular Calcification: A Single Center Study

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ABSTRACT

Background: Vascular calcification has been shown as a critical indicator of cardiovascular diseases and all-cause mortality in patients with chronic kidney disease. Patients with chronic kidney disease and vascular calcification were suggested to be considered at the highest cardiovascular disease risk by the kidney disease. The current study aimed to assess level of sclerostin in patients on haemodialysis and its association with vascular calcification.

Patients and methods: The current study included 29 patients received a renal transplant at least 12 months ago (transplant group), 34 patients who diagnosed wth (end stage kidney disease) ESKD and receiving regular haemodialysis (ESKD group) and 30 normal individuals (control group). All cases were subjected to laboratory data including sclerostin level assessment. In addition, echocardiography and carotid intima media thickness was assessed by Duplex in patient's group.

Results: The study found that majority of subjects was males. Also, frequency of diabetes mellitus was significantly higher among dialysis group. Dialysis group had significtly higher level of sclerostin in comparison to other groups. Vascular calcification was present in 31% of transplant group and 38.2% of dialysis group. Dialysis and transplant groups had significantly higher intima media thickness but with significantly lower bone mineral density in comparison to the control group. Sclerostin had negative significant correlation with glomerular filtration rate and serum calcium and positive significant correlation with serum phosphate, parathermone hormone and intima media thickness. C**onclusion:** Patients with chronic kidney disease are vulnerable to develop vascular calcification. This complication is usually increasing the cardiovascular morbidity in those patients. Multi center future studies are warranted to confirm the role of sclerostin.

Keywords: Vascular calcification, Sclerostin, Intima media thickness.

INTRODUCTION

Abnormalities of mineral and bone metabolism and ectopic calcification, especially vascular calcification (VC), are common in chronic kidney disease (CKD), resulting in a specific class of disease called chronic kidney disease-mineral and bone disorder (CKD-MBD). CKD-MBD, which promotes the development of cardiovascular disease and gives rise to the increased risk of cardiovascular and all-cause mortality, is an extremely important complication of CKD, but it has often been neglected by clinicians [(1)].

Cumulative evidence implies that serum or circulating sclerostin is higher in uremic patients and serum sclerostin increases progressively across the CKD stages. However, the studies on the association of serum sclerostin with VC and mortality in renal disease patients have yielded conflicting results [(2,3)].

The current work was designed to estimate the relation between the level of sclerostin and atherosclerosis/vascular calcification in both end stage renal disease on regular dialysis (ESRD-RD) and renal transplant recipients. Also, to determine relation between serum sclerostin and calcium, phosphorus, parathyroid hormone (PTH), vitamin D levels, bone mineral density.

PATIENTS AND METHODS

This was a case-control study, conducted on 63 patients (29 renal transplant and 34 with ESRD on dialysis) and 30 control subjects, in the period between January 2019 and March 2022. All participants were recruited from the Renal Transplant Clinic and Haemodialysis Unit of Internal Medicine Department, Assiut University Hospital.

Inclusion criteria:

- Both genders.
- Age ≥18 years-old.
- Patients who received a renal transplant at least 12 months ago.
- Patients who diagnosed with ESRD-RD.

Exclusion criteria:

- Age <18 years-old.
- History of tertiary hyperparathyroidism, history suggestive of osteoporosis, and other diseases that might affect bone- mineral status as malignancy.
- Patients who received a renal transplant <12 months ago.

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The study included a total of 93 participants divided into three groups:

- ***Transplant Group*** included 29 patients received a renal **transplant** at least 12 months ago.
- ***Dialysis Group*** included 34 patients who diagnosed with ESKD and receiving regular.
- ***Control Group*** included 30 apparently healthy individuals.

Each patient was subjected to:

A. ***Clinical evaluation*** by thorough history taking and physical examination, including demographic data, history of previous diagnoses/conditions, head-to-toe complete physical examination.

B. ***Imaging*****:**

1. ***Echocardiography*****:** To assess cardiac valve, contractility and systolic and diastolic function.
2. ***Carotid Duplex Examination*****:** All measurements were made by a single examiner who was blinded to the study. A high-resolution B-mode ultrasonography with a 10 MHz transducer was used to make the measurements. Carotid artery IMT (CCA-IMT) was measured as distance between the leading edge of the first bright line (the lumen-intima interface) of the far wall and the leading edge of the second bright line (collagen containing upper layer of tunica adventitia). IMT was measured at three points on the far walls of the left common carotid artery (CCA) 10 mm proximal to the carotid bulb. The IMT of these three locations was then averaged to produce the mean IMT.
3. ***Bone density (DEXA) scan*****:** Bone mineral density (BMD) femoral neck was determined by dual absorptiometry dual-energy (DEXA) scan on femur bone using a Hologic device.

C. Laboratory investigations:

Venous blood (8 mL) was withdrawn for the following investigations; two mL of blood for erythrocytes sedimentation rate (ESR) and six mL of blood separation of serum which was divided into two parts: one part for routine investigations and second part stored at -80° for sclerostin measurement.

Routine investigations included serum creatinine, blood urea nitrogen, (estimated glomerular filtration rate (eGFR) by MDRD equation), C-reactive protein (CRP), calcium level and phosphate, total alkaline phosphatase (ALP) on Advia 1800 chemistry autoanalyzer Siemens-Healthineers, USA. Intact parathyroid hormone (iPTH) by ADVIA Centaur, Siemens-Healthineers, USA. Serum vitamin D level (25-hdroxycholecalciferol) by ELISA.

Measurement of serum sclerostin level was done by sandwich ELISA technique using Human Sclerostin (SOST) ELISA Kit (SinoGeneClon Biotech Co.,Ltd) **(**No.9 BoYuan Road,Yu Hang District 311112, HangZhou, China).

Ethical consideration

The study was approved by the Assiut University Ethics Committee with ID 1000450. The purpose of the study was explained to all participants, and written informed consent was obtained. The study was registered on *clinicaltrials.gov* with NCT0343145. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical analysis

Data was collected and analyzed by using SPSS (Statistical Package for Social Sciences, version 20, IBM, and Armonk, New York). The Shapiro test was used to determine compliance of the data to normal distribution. Quantitative data with normal distribution were given as mean and SD and compared by Student t test and ANOVA, while quantitative data with abnormal distribution were expressed as median (range) and compared by Mann-Whitney U test and Kruskall Wallis. Nominal data were given as number (n) and percentage (%). Chi^2 test was implemented on such data. Correlations of sclerostin with other variables were determined by Spearman correlation. Level of confidence was kept at 95% and hence P-value $\leq$0.05 was considered significant.

RESULTS

Baseline data of the studied groups (Table 1):

The transplant group had significantly higher mean age in comparison to the control group (30.62 ± 5.43 vs. 28.83 ± 5.36) years; *p*= 0.005). Also, dialysis group had significantly higher frequency of DM (44.1% vs. 17.2%; *p*= 0.022) in comparison to transplant group.

Table (1): Baseline data of the studied groups.

Variable	Groups			Significance			
	Transplant (n=29)	Dialysis (n=34)	Control (n=30)	P	P1	P2	P3
Age (years)	30.62 ± 5.43	34.06 ± 7.22	28.83 ± 5.36	0.016	0.104	0.242	**0.005**
Male sex	21 (72.4%)	25 (73.5%)	20 (66.7%)	0.816	0.921	0.632	0.549
Diabetes mellitus	5 (17.2%)	15 (44.1%)	---		0.022	---	
Hypertension	12 (41.4%)	16 (47.1%)			0.651		

Data expressed as frequency (percentage), mean (SD). *P* value was significant if < 0.05

P. value: comparison between all groups, P1: comparison between transplant & dialysis groups, P2: comparison between transplant & control groups, P3: comparison between dialysis & control groups

Baseline laboratory data among the studied groups (Table 2):

Vitamin D level, phosphate and iPTH were significantly higher among dialysis group in comparison to transplant group (33 vs 22, 5.2 vs 4.1, 499 vs 182, respectively, P-values: 0.015, <0.001, <0.001), while serum calcium was significantly higher among transplant group in comparison to Dialysis Group (8.8 ±0.7 vs 8.1±0.6, respectively, P-value: <0.001) (**table 2**).

Dialysis group had the highest level of sclerostin (3122 [810.5 - 4702.25] pg/mL) followed by the transplant group (700 [583.5 – 2555] pg/mL) and control group (165 [138.5 - 305.5] pg/mL).

Table (2): Baseline laboratory data among the studied groups.

Variable	Groups			Significance			
	Transplant (n=29)	Dialysis (n=34)	Control (n=30)	P	P1	P2	P3
Serum creatinine (mg/dl)	1.2 (1.1 - 1.35)	5.3 (3.9 - 6.18)	0.8 (0.7 - 0.9)	<0.001	<0.001	<0.001	<0.001
eGFR (ml/mim/1.73m^2)	63 (51.7 – 74.5)	12 (8 - 15.85)	111.5 (89.53 - 130.5)	<0.001	<0.001	<0.001	<0.001
Serum calcium (mg/dL)	8.79 ± 0.7	8.1 ± 0.62	9.22 ± 0.31	<0.001	<0.001	0.010	<0.001
Serum phosphate (mg/dL)	4.05 ± 0.54	5.19 ± 1.08	3.35 ± 0.28	<0.001	<0.001	<0.001	<0.001
Intact parathermone (pg/mL)	182 (147.5 - 210)	499 (386.25 - 628)	29.5 (21 - 43)	<0.001	<0.001	<0.001	<0.001
Alkaline phosphatase (u/l)	181.2 (154.5 - 199.7)	142 (120.5 - 160.58)	100.6 (88.85 - 118.6)	<0.001	<0.001	<0.001	<0.001
C-reactive protein (mg/dl)	8.16 (4.64 – 12.1)	7.65 (4.58 - 10.03)	3.3 (2.63 - 3.83)	<0.001	0.183	<0.001	<0.001
ESR (mm/hr)	30.8 (20.4 – 38.1)	26.45 (21.53 – 34.58)	13 (9 - 17)	<0.001	0.040	<0.001	<0.001
25-(OH) vitamin D (ng/mL)	22 (16.3 - 28.7)	33 (18.75 - 41.25)	27.5 (18.75 - 39)	0.015	0.006	0.031	0.471
Serum sclerostin (pg/mL)	700 (583.5 - 2555)	3122 (810.5 - 4702.25)	165 (138.5 - 305.5)	<0.001	0.017	<0.001	<0.001

All data expressed as median (range) (not normally distributed data) with exception of serum calcium and phosphate expressed as mean (SD) (normally distributed data). *P* value was significant if < 0.05. eGFR: estimated glomerular filtration rate; ERS: erythrocyte sedimentation rate; OH: hydroxyl.

P. value: comparison between all groups.
P1: comparison between transplant & dialysis groups.
P2: comparison between transplant & control groups.
P3: comparison between dialysis & control groups.

Vascular calcification, IMT and bone mineral density among the studied groups (Table 3):

The frequency of VC was significantly higher among dialysis group when compared to transplant group (38.2% vs 31%, P-value: 0.016) and control group (38.2% vs 6.7%, P-value: 0.003). The average carotid intimal medial thickness (cIMT) was higher in dialysis group (0.88 mm) than transplant group (0.71 mm) and control group (0.46 mm) and this difference was statistically significant (P-value: <0.001).

Table (3): Vascular calcification, IMT and bone mineral density in studied groups.

Variable	Groups			Significance			
	Transplant (n=29)	Dialysis (n=34)	Control (n=30)	P	P1	P2	P3
Valve calcification	19 (65.5%)	22 (64.8%)	8 (26.6%)	**0.001**	0.158	**0.010**	**0.003**
Vascular calcification	9 (31%)	13 (38.2%)	2 (6.7%)	**0.012**	**0.016**	0.101	**0.003**
IMT (mm)	0.71 (0.63 - 0.89)	0.88 (0.72 - 1)	0.46 (0.41 - 0.5)	**<0.001**	0.503	**<0.001**	**<0.001**
FN BMD (g/cm^2)	0.77 (0.69 - 0.92)	0.83 (0.5 - 1)	1.01 (0.94 - 1.04)	**<0.001**	0.825	**<0.001**	**<0.001**
FN T-score	-1 (-1.45 - -0.3)	-0.55 (-2.3 - 0.3)	0 (-0.1 - 0.2)	**<0.001**	0.709	**<0.001**	**0.001**

Data expressed as median (range) (not normally distributed data) or frequency (percentage). *P* value was significant if < 0.05. IMT: intima media thickness; FN: femoral neck. P value: comparison between all groups.
P1: comparison between transplant & dialysis groups, P2: comparison between transplant & control groups, P3: comparison between dialysis & control groups.

Correlation of serum sclerostin with other variables in cases (Table 4):

In case of dialysis Group; sclerostin had significant correlation with age and intima media thickness. While in case of transplant Group; sclerostin had negative significant correlation with eGFR and serum calcium and positive significant correlation with serum phosphate, intact PTH and carotid intima media thickness.

Table (4): Correlation of serum sclerostin with other variables.

Correlation of serum sclerostin level (pg/mL) with	Transplant group		Dialysis group	
	r	p	r	p
Age (years)	0.136	0.482	**0.381**	**0.026**
Serum creatinine (mg/dl)	0.499	0.015	0.027	0.881
Estimated GFR (ml/min/1.73m^2)	**-0.396**	**0.034**	-0.054	0.762
Serum calcium (mg/dL)	**-0.610**	**< 0.001**	-0.097	0.587
Serum phosphate mg/dL	**0.627**	**<0.001**	0.187	0.291
Intact parathormone (pg/mL)	**0.388**	**0.038**	0.151	0.394
Alkaline phosphatase (u/l)	-0.042	0.829	-0.173	0.328
C-reactive protein (mg/dl)	0.252	0.187	0.050	0.780
ESR (mm/hr)	0.243	0.204	-0.069	0.698
Carotid intima media thickness	**0.612**	**<0.001**	**0.523**	**0.002**
FN-BMD (g/cm^2)	0.335	0.075	0.112	0.527
FN T-score	0.366	0.051	0.103	0.561
Serum 25-hydroxyvitamin D (ng/mL)	-0.060	0.759	-0.107	0.545

Data expressed as *r* value (strength of correlation), *p* value (significance of correlation). *P* value was significant if < 0.05. GFR: glomerular filtration rate; FN: femoral neck; BMD: bone mineral density.

Characteristics of transplant group based on VC (Table 5):

Out of the transplant group; 9 (31%) patients had VC and 20 (69%) patients hadn't VC. There were no significant differences between patients with or without VC as regard different characteristics among transplant group (*p*> 0.05).

Table (5): Characteristics of transplant group based on vascular calcification

Variable	Vascular calcification		*P*-value
	No (n= 20)	Yes (n= 9)	
Age (years)	30.25 ± 5.59	31.44 ± 5.27	0.593
Male sex	16 (80%)	4 (20%)	0.180
Diabetes mellitus	4 (20%)	1 (11.1%)	0.498
Hypertension	6 (30%)	6 (66.7%)	0.07
Serum creatinine (mg/dl)	1.20 (1-1.70)	1.30 (1.06-1.62)	0.472
eGFR (ml/mim/1.73m^2)	65.75 (40-90)	51.10 (43.8-85.8)	0.055
Serum calcium (mg/dL)	8.81 ± 0.53	8.74 ± 1.02	0.821
Serum phosphate (mg/dL)	3.90 (3.1-5)	4.20 (3.1-5)	0.562
Intact parathermone (pg/mL)	180 (99-370)	197 (107-219)	0.672
Alkaline phosphatase (u/l)	182.10 (119.6-246.4)	176 (91.5-248.1)	0.982
C-reactive protein (mg/dl)	7.575 (2-19)	9.52 (2.7-15.2)	0.234
ESR (mm/hr)	26.50 (7.2-58.5)	34.20 (11.2-55.8)	0.140
25-(OH) vitamin D (ng/mL)	22.30 (8.80-47.30)	19.50 (9.40-30.80)	0.365
Serum sclerostin (pg/mL)	688 (294-4646)	752 (566-5810)	0.140
Valve calcification	12 (60%)	7 (77.7%)	0.116
IMT (mm)	0.680 (0.46-1.19)	0.80 (0.62-1.26)	0.095
FN BMD (g/cm^2)	0.740 (0.59-1.09)	0.79 (0.65-1.02)	0.340
FN T-score	-1.15 (-2.20-0.90)	-0.90 (-1.50-0.20)	0.501

Data expressed as median (range) in case of not normally distributed data or mean (SD) in case of normally distributed data based on normality of the data. *P* value was significant if < 0.05. eGFR: estimated glomerular filtration rate; ERS: erythrocyte sedimentation rate; OH: hydroxy; IMT: intima media thickness; FN: femoral neck; BMD: bone mineral density.

Characteristics of dialysis group based on vascular calcification (Table 6):

There was a higher serum alkaline phosphates and frequency of DM among VC with lower FN T-score among those with VC. Patients with VC had higher level of serum sclerostin, but statistically insignificant, in comparison to those without VC (4088 (100-7200) vs. 1400 (108-7200) (pg/mL); *p*= 0.362).

Table (6): Characteristics of dialysis group based on vascular calcification

Variable	Vascular calcification		*P*-value
	No (n= 21)	Yes (n= 13)	
Age (years)	34.95 ± 6.54	32.61 ± 8.26	0.367
Male sex	18 (85.7%)	7 (53.8%)	0.051
Diabetes mellitus	6 (28.6%)	9 (69.2%)	**0.024**
Hypertension	10 (47.6%)	6 (46.2%)	0.607
Serum creatinine (mg/dl)	5.70 (2.80-10.10)	4.40 (2.80-9.50)	0.076
eGFR (ml/mim/1.73m^2)	12 (5-27)	12.50 (5-19.2)	0.420
Serum calcium (mg/dL)	8.13 ± 0.589	8.04 ± 0.69	0.821
Serum phosphate (mg/dL)	5.10 (3.4-8.1)	4.70 (4-7.5)	0.529
Intact parathermone (pg/mL)	495 (190-833)	509 (200-1108)	0.972
Alkaline phosphatase (u/l)	135.20 (54-230.5)	159 (87.4-179)	**0.046**
C-reactive protein (mg/dl)	7.50 (0.80-14.2)	8.80 (1.7-13.4)	0.400
ESR (mm/hr)	25.90 (2.80-43)	27.70 (7.9-59.8)	0.276
25-(OH) vitamin D (ng/mL)	35 (7-63)	31 (8-54)	0.232
Serum sclerostin (pg/mL)	1400 (108-7200)	4088 (100-7200)	0.362
Valve calcification	13 (61.9%)	9 (69.2%)	0.826
IMT (mm)	0.88 (0.49-1.31)	0.87 (0.63-1.19)	0.753
FN BMD (g/cm^2)	0.91 (0.44-1.16)	0.66 (0.40-1.13)	0.055
FN T-score	-0.30 (-2.90-1.10)	-1.50 (-3.10-1)	**0.035**

Data expressed as median (range) in case of not normally distributed data or mean (SD) in case of normally distributed data based on normality of the data. *P* value was significant if < 0.05. eGFR: estimated glomerular filtration rate; ERS: erythrocyte sedimentation rate; OH: hydroxy; IMT: intima media thickness; FN: femoral neck; BMD: bone mineral density.

DISCUSSION

Sclerostin is a protein that has signaling pathway exerting anabolic effects on the bone, is likely to also affect the process of vascular media calcification. Despite its well-known role in bone turnover, studies investigating the role of sclerostin in vascular calcification showed controversial results [4].

To study role of sclerostin in VC in dialysis and transplant patients, we conducted this work. The study included 29 patients received a renal transplant at least 12 months ago (transplant group), 34 patients who diagnosed with ESKD and receiving regular haemodialysis (ESKD group) and 30 normal individuals as control group.

In the current study, majority of enrolled participants was males. Also, diabetes mellitus and hypertension were frequently present in dialysis group (44.1% and 47.1%; respectively). It was found that frequency of diabetes mellitus was significantly higher in dialysis group in comparison to control group (44.1% vs. 17.2%; *p*= 0.022).

Gonçalves *et al.* [5] studied a total of 91 patients were on regular haemodialysis. The Majority of patients (55%) were males (mean age 42.3 years). The authors reported that only 15% patients were diabetics. This discrepancy may be attributed to different sample size, study design and studied population.

In the current study, vitamin D, calcium, phosphate and PTH showed significant differences between studied groups. Vitamin D level, iPTH and phosphate were significantly higher among dialysis group in comparison to transplant group while serum calcium was significantly higher among transplant group. **Chevarria *et al.*** [6] stated that rapid effects of renal transplantation include reduced serum PTH levels (even where serum calcium levels are stable), increased calcium production and decreased serum phosphate levels.

The current study found that the dialysis group the highest level of sclerostin followed by the transplant group and control group. Till our knowledge, this is the first reported study that compared level of sclerostin between transplant and dialysis groups.

In addition, **Figurek and Spasovski** [7], showed that sclerostin levels were markedly increased in patients with CKD on regular dialysis than in healthy controls. A another study done by **Kalousová *et al.*** [8] showed that in long-term hemodialysis patients, the serum sclerostin levels are increased to about three times higher compared with normal participants.

In the current study, we found that frequency of VC was significantly higher in dialysis (38.2%) and transplant group (31%) in comparison to control group (6.7%). Also, frequency of valvular calcification was significantly higher in dialysis (64.8%) and transplant group (65.5%) in comparison to control group (26.6%).

VC is common among CKD patients. Reported prevalence rates ranged from 40% in patients with CKD stage 3, to 90% in patients with end stage renal disease [4,9-12]. Variability between studies is substantial, which may be explained by case-mix, differences in arterial territories analyzed and in sensitivity of imaging techniques used.

Studies on the natural history of vascular calcification (VC) in renal transplant recipients (RTRs) are scarce and so far yielded discrepant findings. These discrepancies most probably reflect differences in case-mix and duration of follow-up, but may also relate to methodological issues [13].

As regard valvular calcification, in line with current study, **Matsuo *et al.*** [14] demonstrated that 76.5% and 58.4% of ESRD patients receiving HD had aortic and mitral valvular calcification, respectively. They also showed that approximately half of the patients had aortic valve narrowing < 2.0 cm^2. Importantly, valvular stenosis progresses more rapidly in ESRD patients receiving HD than those with earlier stages CKD [15,16].

In the current study, we found that IMT was significantly higher in dialysis and transplant groups in comparison to the control group. CKD is an independent risk factor for cardiovascular disease. The association between carotid IMT and CKD is controversial, however. In addition, whether renal dysfunction promotes vascular calcification in patients with chronic kidney disease is not clear [17,18].

Comparable with these findings, a previous study found that mean CIMT thicknesses were 0.86 (SD 0.16) mm in the dialysis group and 0.61 (SD 0.11) mm in the control group. Mean CIMT was significantly higher in the patient group ($p < 0.001$) and valve calcification was measured as 53% in the patient group. Aortic valve calcification was 22.5%, mitral valve calcification in 18.3%, and calcification in both valves in 12.2%. The rate of valve calcification in the control group was 10.4% [19].

Also, we found that both dialysis and transplant groups had significantly lower FN-BMD and FN T score in comparison to the control group. It's known that progression of renal diseases leads to increased PTH secretion, causing hyperparathyroidism secondarily. This results in renal osteodystrophy and its advanced type called brown tumors [20].

In the current study, in case of dialysis group; sclerostin had positive significant correlation with age and intima media thickness. While in case of transplant group; it had negative significant correlation with eGFR and serum calcium and positive significant correlation with serum phosphate, intact PTH and carotid intima media thickness.

In line with the current study, **Mohamed *et al.*** [21] showed that sclerostin levels in patients with CKD revealed a significant negative association with the classical CKD-MBD biomarkers, such as intact PTH,

phosphorus, calcium phosphorus product, and albumin. However, in patients with ESRD, there was only significant association with PTH. Moreover, there was no association with C-reactive protein.

Similarly, other studies have shown the connections between elevated sclerostin level and a decrease in the prevalence and severity of vascular calcifications [22, 23]. Most probably, sclerostin may restrain the progression of vessel calcification by a similar mechanism of antagonizing bone formation [8].

On the contrary, other studies had been published, proving a positive relation between high sclerostin levels and vascular/valvular calcification in patients with renal disease. In contrast to our study were the study by **Qureshi *et al.*** [24] and **Wang *et al.*** [25], where in the study by Qureshi and colleagues, the increased sclerostin levels were described as a positive predictor of vascular calcifications.

We acknowledge several additional limitations of the present study, including its cross-sectional nature, and single dialysis center. These limits affect the establishment of a definitive causal relationship between sclerostin and vascular calcification. Moreover, we used only one assay to test the parameters, thereby limiting our ability make universal claims regarding associative data between biomarkers with vascular calcification.

We didn't used computed tomography in assessment of IMT where it could provide high-resolution, three-dimensional images for precise diagnostics [26]. And yet our study considered the first one that compared between dialysis and transplant groups as regard sclerostin.

In conclusion, VC is common in patients with CKD. Early detection of VC in those patients is allowing early intervention with subsequent good outcome. Based on the current study, sclerostin was higher in patient groups and yet couldn't be used as a predictor for VC in patients with CKD. So, future studies are warranted about that issue

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