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Original

Bone mineral density and bone metabolism biochemical markers in patients with chronic kidney disease at the hemodialysis treatment

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Abstract

Introduction: Chronic kidney disease (CKD) is associated with bone and mineral metabolism disorders.

Objectives: This study investigated the bone mineral density (BMD) and bone metabolism biochemical markers in patients with CKD at the hemodialysis treatment among Iranian adults as well as the relationship between possible risk factors or biochemical markers with BMD.

Patients and Methods: In this cross-sectional study, 77 patients with CKD stage 5D at the hemodialysis treatment were selected from September 2016 to February 2016. BMD was measured by dual-energy X-ray absorptiometry (DEXA) at the anteroposterior lumbar spine (LS) (L1-L4) and left proximal femur. Biochemical markers including calcium (Ca), phosphorus (P), intact parathyroid hormone (iPTH), serum specific alkaline phosphatase (serum AP) and 25-hydroxy-vitamin D (25hD) were used for the prediction of BMD loss.

Results: Two (2.6%) patients had normal levels of 25hD (mean levels 17.67 ± 11.66 µg/L). We found a reduction of BMD in comparison with age- and gender-matched normal population values at the femoral neck (FN) (T-score = -1.92 ± 1.29), at the total hip (TH) (T-score = -1.79 ± 1.25) and at the LS (T-score = -1.55 ± 1.84). The prevalence of T-scores ≤-2.5 SD was 28.6%, 35.1% and 13.0% according to the LS, FN and three bone sites T scores respectively. BMD negatively correlated with age at the proximal femur, with serum AP at the LS and with age of menopause at the FN.

Conclusions: Patients with CKD at the hemodialysis treatment had a high prevalence of osteoporosis in the general population. BMD at the all bone sites was below the expected average for gender and age.

Keywords: Bone mineral density, Chronic kidney disease, Hemodialysis, Biochemical markers, Osteoporosis

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Introduction

Impaired renal function is a well-established risk factor for reduced bone mineral density (BMD) and development of osteoporosis (1,2). Metabolic changes, such as increased phosphate levels, chronic metabolic acidosis, secondary and tertiary hyperparathyroidism, and abnormal synthesis of 1.25-dihydroxyvitamin D alter bone mineralization or turnover and cause lower BMD in chronic kidney disease (CKD) (3,4). CKD is associated with higher serum concentrations of bone turnover markers (5). Serum phosphate, calcium (Ca), serum specific alkaline phosphatase (serum AP), bone-specific alkaline phosphatase (BSAP), and parathyroid hormone (PTH) are widely used surrogate markers of turnover bone disease in CKD patients (6). Elevated PTH levels cause an anabolic effect on trabecular bone and catabolic effects on cortical bone and it is progressively increased as kidney function declines (5).

Patients with CKD are at increased risk of bone loss, even with minimal reduction in kidney function (7). The effects of the hemodialysis period on BMD and biochemical markers of bone metabolism in developing countries have not been well studied (8). It is reasonable to assume that some patients with CKD have other disorders of bone that contribute to renal osteodystrophy. The most prevalent bone disorder is osteoporosis, but little attention has been paid to its possible contribution to patients with CKD, particularly in the CKD patients at the hemodialysis treatment (9). Recently proposed by the "Kidney Disease: Improving Global Outcomes" working group that osteoporosis should and could be included in the broad characterization of CKD mineral and bone disorder. In fact, it is reasonable to assume that why osteoporosis cannot accompany the derangements in bone metabolism

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Implication for health policy/practice/research/medical education

Chronic kidney disease (CKD) is associated with bone and mineral metabolism disorders. It should be noted that this bone disorder is multifactorial and complex and bone mineral density alone may not be adequate to characterize the bone disease associated with end-stage renal disease.

that characterize CKD (10,11).

Dual-energy X-ray absorptiometry (DEXA) is a rapid, precise and standard non-invasive procedures to determine BMD in healthy kidney function. However, the results on the power of DEXA to predict BMD loss in CKD patients at the hemodialysis treatment are controversial and contradictory. Nickolas et al (12) reported that DEXA did not discriminate bone loss in CKD. Combining biochemical markers with BMD could improve the discriminatory ability of DEXA to predict BMD loss in CKD (13). Hence, the present study aimed to usefulness of several bone turnover related biochemical markers and BMD also to determine potential risk factors for reduced BMD in Iranian patients with end stage renal disease (ESRD). Thus, the management of disease process by assessing biochemical markers and BMD can help to early diagnose bone and mineral disorders and thus to prevent adverse consequences and poor outcome in CKD patients. In addition, although our knowledge with respect to the risk profiles and outcomes associated with bone disorders in CKD patients has evolved, less is known about biochemical status and bone disease risk factors in Iranian ESRD patients.

Patients and Methods

Study population

In this cross sectional study, 77 established ESRD patients matching the inclusion criteria were consecutively recruited between September 2016 and February 2016. Patients studied at the dialysis center of Kowsar hospital at the Semnan University of Medical Sciences, Semnan, Iran were selected using the census method. The inclusion criteria included age ≥18 years, hemodialysis treatment ≥12 months (3 times in weak) and estimated glomerular filtration rate (eGFR) < 0.25 mL/s/1.73 m^2. All patients were clinically stable. History of malignancy, previous kidney transplantation, history of osteoporotic fracture, patients who were currently taking medication known to influence bone metabolism (such as glucocorticoid, immunosuppressive agents, hormone replacement therapy, heparin or anticoagulants), previous history of bone disorders such as Paget's disease or other bone-related metabolic disorders were excluded from the research. All patients was taking calcium carbonate (1-2 g/d), and Nephrovit or Nephrotonic (daily). Use of doxercalciferol, paricalcitol or calcitriol was defined as use of active vitamin D supplementation.

Ethics issues

This study was conducted with the approval of the Medical Ethical Committee of the Semnan University of Medical Sciences. All participants provided written informed consent prior to study enrollment according to the Declaration of Helsinki (General Assembly October 2008).

Biochemical and corporeal measurements

Ten milliliters of venous blood was taken from the brachial vein, placed in tubes and centrifuged for 10 minutes at 3000 rpm to separate serum from cells. These samples were collected before hemodialysis treatment, after an overnight fast. The serum samples were immediately frozen at -40°C. Intact parathyroid hormone (iPTH) was measured with a Siemens Immulite 2000 Xpi device using an chemiluminescent method and normal range 12-56 pg/mL (1.3 – 6.8 pmol/L); and 25-hydroxy-vitamin D (25hD) was measured by Awareness STAT fax – 2100 devise using an ELISA method and Deutschland Euroimmun kit; other biochemical parameters including Ca, phosphorus (P) and serum AP were measured using a Hitchi 912 automatic analyzer device and measured employing routine laboratory procedures. IPTH levels were categorized into three groups (<100, 100–300, ≥300). Total Ca was corrected by adding 0.8 mg/dL for every 1.0 g/dL, by which the albumin is <4 g/dL. These markers were measured repeatedly twice a month within a 2-month period before measurement of BMD. The mean value of 4 assays was taken for further evaluation. In addition to collecting baseline characteristics and medical history (including age, age at menopause) by interviewing, the patients subjected to physical examination. The body weight was measured using a single scale calibrated by the researchers and height was also measured using a statiometer (Seca) without shoes. Body mass index (BMI) was calculated as weight (kg) divided by the square of height (m^2).

Bone mineral density measurements

Determination of BMD was performed on a Fan Beam x-Ray bone densitometry device (Safir Inc.) using DEXA. The sections for detection included the two areas of the central skeleton, at the anteroposterior lumbar spine (LS) (L1 through L4) and at the left proximal femur (at the total hip [TH] and the femoral neck [FN]). Results were expressed as T and Z scores. T score was defined as the number of standard deviations (SDs) lies below the mean BMD for a sex-matched young healthy population. Based on the WHO Osteoporosis Classification, patients were also categorized to have normal BMD (T-score ≥−1.0), osteopenia (T-score= −1.0 to −2.5) or osteoporosis (T-score <−2.5) groups (14). Z score was used to represent the standard deviation (SD) below the mean BMD value that was normalized for a sex-matched and age-matched healthy population. T and Z scores are also expressed as a

percentage. The DEXA machine coefficient of variation was 1.0% in the proximal femur and 0.7% in the LS and.

Statistical analysis

Data were analyzed with the statistical software SPSS version 16.0 for windows (SPSS Inc., Chicago, IL), using student's *t* test (for the comparison between the two groups), chi-square test (for the comparison categorical variables) and one-way analysis of variance (ANOVA) test (for the comparison of parameters between groups). The relationship between parameters was evaluated by Pearson correlation analysis. All results were expressed as the mean ± SD for quantitative variables and were summarized by absolute frequencies and percentages for categorical variables, otherwise variable SDs were stated as the median value. $P<0.05$ was considered statistically significant. Results were presented as mean ± SD.

Results

Demographic and biochemical data

The study enrolled 77 patients with CKD at the hemodialysis treatment, 39 (50.6%) males, 38 (49.4%) females, and with mean age of 62.27±14.93 years. Three patients (3.9%) were under the age of 39 years (early adulthood), 20 patients (26%) between 40 and 59 years (middle adulthood) and 54 patients (70.1%) over the age of 60 years (old age). Causes of CKD were: diabetic nephropathy (n = 41, 53.2%), hypertensive nephrosclerosis (n = 15, 19.5%), chronic glomerulonephritis (n = 55, 71.4%) and unknown (n = 16, 20.8%). Severe deficiency of 25hD (5-10 nmol/L) was found in 14.3%, mild deficiency (11-20 nmol/L) in 64.9%, suboptimal (21-30 nmol/L) in 5.2%, and optimal (31-50 nmol/L) in 6.5%. Two (2.6%) patients had normal levels of 25hD (>51 nmol/L). Levels of 25hD were significantly lower in female than in male (14.57 ± 7.27 vs. 20.72 ± 14.18 µg/L, $P=0.019$) and in diabetics than in non-diabetics patients (16.73 ± 10.60 vs. 18.73 ± 12.82 µg/L, $P=0.048$). Levels of iPTH were significantly lower in diabetics than in non-diabetics (427.95 ± 53.25 vs. 695.72 ± 53.25 pg/mL, $P=0.028$). Other demographic and biochemical information are presented in Table 1.

Bone mineral density

The lowest values of BMD expressed in g/cm^2 were found at the FN, while the highest were found at the LS, where mean FN, TH and LS T scores were -1.92 ± 1.29, -1.79 ± 1.25 and -1.55 ± 1.84, respectively. According to the LS T scores, 22 (28.6%) patients were normal, 33 (42.9%) patients were osteopenic, and 22 (28.6%) patients were osteoporotic. According to the FN T scores, 15 (22.0) patients were normal, 35 (45.4%) patients were osteopenic, and 27 (35.1%) patients were osteoporotic (Table 2). Ten patients (13.0%) had generalized osteoporosis with reduced BMD in three sites. Prevalence of osteoporosis was significantly lower in male than in female patients (5.1% vs. 47.4%, $P<0.001$). BMD T scores in three sites including LS, FN and TH were significantly lower in female than in male patients (all $P<0.05$) (Table 3).

As summarized in Table 4, none of T scores measured in different bone sites were different according to the baseline disorders status including diabetes mellitus, hypertension, chronic glomerulonephritis, or vitamin D deficiency ($P>0.05$).

There were not significant difference between T-scores for femoral neck, total hip and lumbar spine in patients with various levels of vitamin D and iPTH (Table 5).

There was a negative correlation between age with BMD T scores of FN ($P=0.016$, R = -0.275) and TH ($P=0.018$, R = -0.270) and between BMD T scores of LS with serum AP ($P=0.023$, R = -0.263), whereas a positive correlation was seen with body weight ($P=0.003$, R = 0.340 with FN and $P=0.003$, R= 0.334 with TH). There was a negative correlation between BMD T scores of FN with age of

Table 1. Demographic and Biochemical Data

Variables	Range	Mean ± SD
Age (y)	24.00-85.00	62.27 ± 14.93
BMI (kg/m^2)	14.61-41.02	24.60 ± 4.76
iPTH (pg/mL)	43.00-2700.00	553.14 ± 640.20
25hD (µg/L)	7.00-72.00	17.67 ± 11.66
Serum AP (U/L)	54.60-1903.00	384.35 ± 33.04
Ca (mg/dl)	8.20-11.00	9.00 ± 0.64
P (mg/dl)	3.40-6.80	4.95 ± 0.56
Ca × P	34.00-69.36	44.56 ± 6.44
eGFR (mL/s/1.73 m^2)	0.10-0.25	0.16 ± 0.04

Abbreviations: 25hD, 25-hydroxy-vitamin D; BMI, body mass index; iPTH, intact parathyroid hormone; Serum AP, serum-specific alkaline phosphatase; Ca, calcium; P, phosphorus; Ca × P, calcium phosphate product; eGFR, estimated glomerular filtration rate.

Table 2. Distribution of bone density status according to femoral neck, total hip and lumbar spine densitometry

Bone density status (BMD T scores)	FN		TH		LS	
	No.	%	No.	%	No.	%
Normal (≥-1)	15	19.5	22	28.6	22	28.6
Osteopenic (-2.49 to -0.99)	35	45.5	35	45.5	33	42.9
Osteoporosis (≤-2.5)	27	35.1	20	26.0	22	28.6

Abbreviations: LS, lumbar spine; FN, femoral neck; TH, total hip.

Table 3. Comparison of BMD findings by gender

Variables (g/cm^2)		Mean ± SD		*P*
		Male (n = 39)	Female (n = 38)	
LS	T score	-1.02 ± 1.47	-2.09 ± 2.03	0.006[a]
	Z score	-0.92 ± 1.99	-1.10 ± 2.08	0.037[a]
FN	T score	-1.59 ± 1.07	-2.25 ± 1.43	0.020[a]
	Z score	-0.54 ± 1.14	-0.92 ± 1.20	0.032[a]
TH	T score	-1.44 ± 0.96	-2.16 ± 1.42	0.037[a]
	Z score	-0.92 ± 1.13	-1.26 ± 1.30	0.006[a]

Abbreviations: LS, lumbar spine; FN, femoral neck; TH, total hip; P, comparison between females and males.

[a] $P<0.05$ is significant.

menopause ($P=0.040$, R=-0.370). This correlation analysis remains significant when weight adjusted. There was no correlation between BMD T scores and other biochemical factors (Table 6).

Significant factors influencing BMD results selected by stepwise multiple linear regression analyses using LS FN and TH BMD as dependent variables are presented in Table 7. The selection was carried out among the factors listed in Table 1, including gender and diabetes mellitus. Stepwise multiple linear regression analyses revealed higher age and lower weight as the main predictors for reduced BMD in TH. Similar multivariate analysis also showed that low body weight was only determinant for decreased BMD in FN. According to the findings of similar model, none of the mentioned variables could predict decreased BMD in LS (Table 8).

Discussion

The study found a high prevalence of 25hD deficiency in our CKD patients at hemodialysis treatment. This result is known to be common in hemodialysis patients with CKD (11,16). This finding suggests the possibility of a significant number of hemodialysis patients with osteomalacia in our study. We found significantly lower levels of 25hD in diabetics females than in non-diabetics and males, which is in agreement with results of other studies (16-18).

Table 4. BMD T scores with clinical findings of the patients

Variables		Mean ± SD		
		T (FN)	T (TH)	T (LS)
DM	Present (n = 41)	-1.81 ± 1.22	-1.72 ± 1.10	-1.60 ± 1.37
	Absent (n = 36)	-2.00 ± 1.37	-1.84 ± 1.43	-1.41 ± 2.27
	P	0.530	0.687	0.640
HTN	Present (n = 55)	-1.84 ± 1.35	-1.81 ± 1.29	-1.53 ± 1.89
	Absent (n = 22)	-2.03 ± 1.15	-1.69 ± 1.18	-1.47 ± 1.71
	P	0.569	0.703	0.903
GN	Present (n = 5)	-2.64 ± 1.11	-2.16 ± 1.27	-2.08 ± 1.79
	Absent (n = 7)	-1.85 ± 1.29	-1.75 ± 1.26	-1.47 ± 1.84
	P	0.185	0.484	0.478

Abbreviations: DM, diabetes mellitus; HTN, Hypertension; GN, Chronic glomerulonephritis; T (FN), T score for femoral neck, T (TH), T score for total hip; T (LS), T score for lumbar spine; *P*, comparison between each variable.

Measured levels of iPTH were lower in diabetic than in non-diabetic patients. It is known that hemodialysis patients with diabetes mellitus (DM) are often characterized by a reduced bone remodeling and relative hypoparathyroidism (19). Poor glycemic control in hemodialysis patients with DM is associated with lower iPTH levels (20).

Stepwise multiple linear regression analyses showed no association between BMD and eGFR. Jamal et al did not find that deteriorating kidney function with bone loss increased with (8). Therefore, we identified that BMD results cannot be vindicated by the relatively small differences in the eGFR.

We identified a reduction in BMD expressed in g/cm^2, especially at the FN and to a lesser extent, also at the TH. In contrast, the mean value of BMD T scores at the LS was within the normal range and the values of BMD Z scores was actually above the average value expected for sex and age-matched and controls. Meta-analysis published in KDIGO guidelines showed that in proximal femur and forearm (areas with a greater proportion of cortical bone), Z-scores for hemodialysis patients with CKD were approximately -0.5 to -1 SD; but at the LS, Z-scores in persons without known CKD were closer to the average (21). These differences could arise for several reasons. The effects of increased iPTH may be different on trabecular and cortical bone and be dependent on the hyperparathyroidism severity (22). Since the proximal femur contains more trabecular and cortical bone than the vertebral body, severity of hyperparathyroidism may have a different effect on DEXA findings at the LS and in the area of the FN and TH. In addition, artifacts can cause inaccuracies in DEXA measurements in the LS. Any Ca in the path of the X-ray beam caused false elevation in the BMD measurement (aortic calcifications, osteophytes, osteoarthritis with hyperostosis, degenerative disc disease, etc) (9,22,23).

The study found a higher prevalence of T score and lower BMD values corresponding to osteoporosis in female than in male patients. This finding is consistent with data in the general population (24,25). Several studies of dialysis patients with CKD have reported the same findings (26,27).

Table 5. BMD T scores with vitamin D and PTH level

Variables		Mean ± SD		
		T (FN)	T (TH)	T (LS)
Vitamin D	Deficient (≥10 ng/mL) (n = 11)	-1.80 ± 1.74	-1.67 ± 1.39	-0.99 ± 2.28
	Insufficient (11-20 ng/mL) (n = 50)	-1.95 ± 1.15	-1.85 ± 1.18	-1.78 ± 1.72
	Optimal (>20 ng/mL) (n = 16)	-1.89 ± 1.42	-1.68 ± 1.43	-1.17 ± 1.84
	P	0.936	0.850	0.291
iPTH	Normal (n = 5)	-1.67±0.82	-1.78±1.13	-0.88±1.48
	Hyper Para (n = 72)	-1.93±1.32	-1.79±1.26	-1.59±1.86
	P	0.672	0.980	0.407

Abbreviations: T (FN), T score for femoral neck, T (TH), T score for total hip; T (LS), T score for lumbar spine; IPTH, intact parathyroid hormone; *P*, comparison between each variable.

Table 6. Correlation of BMD levels with clinical and biochemical findings

Variables	Correlation index	T (FN)	T (TH)	T (LS)
Age (y)	Coefficient	-0.275	-0.270	-0.132
	P	0.016[a]	0.018[a]	0.257
Body weight (kg)	Coefficient	0.340	0.334	0.177
	P	0.003[a]	0.003[a]	0.125
BMI (kg/m^2)	Coefficient	0.209	0.192	0.037
	P	0.071	0.097	0.751
Age of menopause	Coefficient	-0.370	-0.251	-0.026
	P	0.040[a]	0.173	0.891
P (mg/dL)	Coefficient	0.020	-0.047	-0.109
	P	0.863	0.687	0.348
Ca (mg/ dL)	Coefficient	0.020	-0.052	-0.165
	P	0.862	0.655	0.154
Serum AP (U/L)	Coefficient	-0.211	-0.214	-0.263
	P	0.069	0.065	0.023[a]
25hD (µg/L)	Coefficient	0.061	0.163	0.133
	P	0.600	0.161	0.253
iPTH	Coefficient	-0.204	-0.128	-0.131
	P	0.075	0.266	0.257

Abbreviations: 25hD, 25-hydroxy-vitamin D; BMI, body mass index; Serum AP, serum-specific alkaline phosphatase; Ca, calcium; P, phosphorus; IPTH, intact parathyroid hormone; T (FN), T score for femoral neck, T (TH), T score for total hip; T (LS), T score for lumbar spine; *P*, comparison between each variable.

In this study, no statistically significant differences were found in either the prevalence of osteoporosis or T scores measured according to the baseline disorders status including DM, HTN, chronic glomerulonephritis, or vitamin D deficiency. In this regard, the presence of osteoporosis was not significantly associated with the presence of mentioned underlying disorders. The results of studies dealing with BMD in patients with DM in the general population are inconsistent. However, a recent meta-analysis involving 19 139 non-diabetics and 3437 diabetics showed that BMD in patients with DM type 2 was significantly higher in the area of the SL and at the proximal femur (28). Several studies of dialysis patients with CKD reported different conclusions: no difference between non-diabetics and diabetics (29), lower BMD in diabetics (30), or higher BMD at the forearm but no difference at the spine (31).

In our study, prevalence of osteoporosis was 47.4% in females and 5.1% in males. Studies in the general population reported a lower prevalence of osteoporosis in female patients. The estimated prevalence of osteoporosis in Sweden was 21.2% in females and 6.3% in males (32), while data from Canadian survey from 2009 showed the prevalence to be 19% and 3%, respectively (24). According to a Germany survey from 2003, 39% of females and 9.7% of males have been diagnosed with osteoporosis (33). The prevalence of low BMD is increased among CKD patients. Hemodialysis patients with CKD are affected by bone disease associated with CKD and also share similar risk factors for osteoporosis with the general population (9,34,35). It should be noted that this bone disorder is multifactorial and complex and BMD alone may not be adequate to characterize the bone disease associated with CKD (9,11).

In the present study, there was no relation between BMD

Table 7. Correlation of iPTH with vitamin D levels

			iPTH		*P* (Fisher exact test)
			Normal (12-56) (pg/mL)	Hyper Para (>56) (pg/mL)	
Vitamin D	Low (≤20 ng/mL) (n=61)	No.	3	58	0.276
		%	4.9	95.1	
	Optimum (>20 ng/mL) (n=16)	No.	2	14	
		%	12.5	87.5	
Total		No.	5	72	
		%	6.5	93.5	

Abbreviations: iPTH, intact parathyroid hormone; P, comparison between each variable.

Table 8. Linear multiple regression analyses using LS, FN and TH BMD as dependent variables entering all subjects of interest

Variables	TH (R^2 = 0.336)			FN (R^2 = 0.362)			LS (R^2 = 0.165)		
	Regression coefficient	SE	*P*	Regression coefficient	SE	*P*	Regression coefficient	SE	*P*
Constant	0.751	1.061	0.482	1.265	1.075	0.243	1.999	1.751	0.258
Sex (female)	-0.828	0.259	0.002[a]	-0.870	0.263	0.001[a]	-1.056	0.428	0.016[a]
BMI	0.065	0.026	0.016[a]	0.068	0.027	0.013[a]	0.017	0.043	0.696
Age	-0.041	0.009	0.000[a]	-0.045	0.009	0.000[a]	-0.031	0.015	0.043[a]
Serum AP	-0.001	0.000	0.109	-0.001	0.000	0.049[a]	-0.001	0.001	0.088
iPTH	-0.001	0.000	0.017[a]	-0.001	0.000	0.002[a]	0.000	0.000	0.518
Vitamin D	0.009	0.011	0.423	-0.004	0.011	0.724	0.007	0.019	0.720

Abbreviations: BMI, body mass index; Serum AP, serum-specific alkaline phosphatase; IPTH, intact parathyroid hormone; FN, femoral neck, TH, total hip; LS, lumbar spine; *P*, comparison between each variable.

[a] $P < 0.05$ is significant.

T scores with Ca levels. Several studies in CKD patients have previously reported this finding (36,37). It should be noted that Ca levels in our study and the similar studies were measured only before the BMD determination and therefore do not reflect the long-term impact of Ca levels on BMD.

We identified a positive correlation between body weight (BW) and BMD at the regions of the proximal femur (FN and TH). In the general population, low body weight is known to be a risk factor for low BMD. Several studies in patients with CKD observed the same finding (37-39).

This study has several limitations. First, we did not obtain data in a healthy control group. Second, DEXA may not discriminate trabecular and cortical bone. This may restrict the power of DEXA in CKD patients. Third, due to the values of eGFR and BMD varying across ethnicity, the findings may be contradictory. Finally, the impossibility of assessing other factors, such as nutrition state, is the other limitations of this study. Moreover, the authors tried to control the environmental conditions affecting the values and laboratory variables, in order to achieve reliable results.

Conclusion

The present study showed a high prevalence of osteoporosis in hemodialysis patients with CKD in comparison with the general population. Age was negatively correlated with BMD, whereas weight positively correlated with BMD at the proximal of femur. Serum AP was negatively correlated with BMD only at the LS, whereas age of menopause correlated only in the area of the FN. Therefore, menopause, age, Serum AP and weight may affect loss of bone density in patients with CKD. Osteopenia was more common than osteoporosis. This study confirmed a high prevalence of 25hD deficiency, especially in females and diabetics. A significant reduction of BMD T scores was found in the area of the FN and TH, but not at the LS. These differences could arise from the different effects of increased iPTH on trabecular and cortical bone as well as the frequent false elevation of BMD in the LS. The present study further demonstrated that several bone metabolism biochemical markers and BMD measurements were useful for the diagnosis of bone status in the hemodialysis patient with CKD. There is a need for further studies on novel serum bone turnover markers and novel BMD measurement techniques to determine bone loss quantity in these patient groups.

Conflicts of interest

The authors declare that they have no conflict of interests.

Ethical Considerations

Ethical issues (including plagiarism, data fabrication, double publication) have been completely observed by the authors.

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