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Original Article

Comparison of computed tomography bone mineral density (BMD) with vitamin D levels

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ABSTRACT

Objective: To compare the CT-bone mineral density (CM-BMD) with the vitamin D levels.

Methodology: A cross-sectional study was conducted from April 1st, 2023, to March 31st, 2024, at the Radiology Department, CMH Bahawalpur. One hundred patients presenting with bone pain who were referred to the radiology department for CT-BMD were included in the study. After baseline characteristics, vitamin D levels (25-OHD) were measured and categorized as ≥30 ng/mL as normal, 21-29 ng/mL insufficient, and ≤20 ng/mL as deficient. BMD was measured using computed tomography of the lumbar spine at L1-L4. A T-score of > -1 was considered normal, between -1 and -2.5 as osteopenia, and < -2.5 as osteoporosis. The data was analyzed using SPSS 26. The association of CT BMD vitamin D levels was calculated using the chi-square test.

Results: The mean age of the patients was 55.05±10.54 years, comprising 31% males. The mean BMI was 26.17±3.20. The mean vitamin D level among patients was 22.22±10.35, with 59.0% as deficient, while the mean CT BMD was -1.85±1.14, with 29.0% with osteoporosis. However, about 11% of patients with osteoporosis had normal vitamin D levels. Both variables had a significant association when vitamin D was compared with CT-BMD ($p<0.001$). When data were stratified, normal BMI patients, overweight, and rural residents had no significant effect on the association.

Conclusion: Our study concluded that CT BMD-reported osteoporosis is significantly associated with deficient vitamin D levels.

Key Words: *Bone Mineral Density; Bone Density; Bone Pains; Vitamin D; Osteoporosis; Osteopenia*

1. INTRODUCTION

Osteoporosis (OP) is a systemic skeletal disorder that predominantly impacts older individuals and postmenopausal women. [1] It is characterized by diminished bone mineral density (BMD) and microarchitectural deterioration of bone tissue, rendering bones weaker and more susceptible to fractures. [2] The incidence of osteoporosis approaches 200 million globally and is rising dramatically. [3] Approximately 9.9 million individuals in Pakistan are afflicted by osteoporosis, with 7.2 million of them being female. [4] The severity of osteoporotic fractures depends on bone mineral density. BMD, as measured by a DEXA scan or computed tomography, can identify osteoporotic fracture risk. [5] DEXA scan is recommended; however, soft tissue, vascular calcifications, bowel contents, and degenerative spine alterations can affect predicted bone mass readings. Quantitative CT provides the same diagnostic accuracy as DEXA and better spinal BMD sensitivity. [6, 7]

Nutrition, particularly calcium and vitamin D, has a significant impact on the prevalence of osteoporosis. Insufficient vitamin D levels affect the formation and activity of osteoblasts and osteoclasts, which regulate mineral metabolism and bone remodeling, thereby contributing to osteoporosis.[8-10] A study indicated that the prevalence of osteoporosis was 36.8% in individuals with insufficient Vitamin D levels, compared to 7.6% in those with normal levels. [11]

Notwithstanding an area characterized by a prolonged summer season, a study indicated that roughly 73% of the population suffers from vitamin D insufficiency in South Asia.[12] We posited that vitamin D insufficiency correlates with reduced bone mineral density and osteoporosis. Due to the scarcity of local data, we evaluated the severity using CT of the lumbar spine, as most patients present with their first back pain. This study examines the relationship between CT-BMD and vitamin D levels.

2. METHODOLOGY

A cross-sectional observational study was conducted from April 1, 2023, to March 31, 2024, at the Radiology Department of the Combined Military Hospital, Bahawalpur. After the approval of an ERB (CPSP/REU/RAD-2022-034-3702; dated 7th March 2023) and informed consent, 100 patients were included, keeping in view the sample size based on a percentage of osteoporosis in normal vs. decreased vitamin D levels (7.6% vs. 36.8%) [11] at a confidence limit of 5%, and a power study of 90%. Individuals aged 18-50 years of both sexes, presenting with bone pain from the outpatient or rehabilitation department and referred to the radiology department for CT-BMD, were included in the study. Patients with established organ failure, chronic medical conditions, those on drugs that may modify vitamin D levels or influence bone mass, as well as pregnant, nursing, and postpartum women, were excluded.

After obtaining informed consent, a comprehensive history and physical examination were conducted, and patients meeting the inclusion criteria were enrolled in the study. Baseline parameters, including age, gender, BMI, and domicile (rural/urban), were documented. A fasting specimen was collected to assess vitamin D levels (25-OHD). Serum 25 (OH) D concentrations were quantified by radioimmunoassay. A ≥30 ng/mL vitamin D level was deemed normal, 21-29 ng/mL insufficient, and ≤20 ng/mL deficient. Patients were categorized into three groups based on 25-OH D levels: normal, inadequate, and deficient. BMD was assessed using computed tomography of the lumbar spine at L1-L4, resulting in a T-score. We defined a T-score greater than -1 as usual, between -1 and -2.5 as osteopenia, and less than -2.5 as osteoporosis, per WHO guidelines. [13]

The data was analyzed using SPSS 26. Qualitative data were presented as percentages and frequencies, while quantitative data were presented as means and standard deviations. The association of CT BMD (normal/osteopenia/osteoporosis) and vitamin D levels (normal, insufficient, and deficient) was calculated using the Chi-square test. Effects were modified, and confounders were controlled using data stratification.

3. RESULTS

The mean age of the patients was 55.05±10.54 years, with 31% of the patients being male. The mean BMI was 26.17±3.20. The descriptive statistics are shown in Table I. The mean vitamin D level among patients was 22.22±10.35, with 59.0% as deficient, while the mean CT BMD was -1.85±1.14, with 29.0% with osteoporosis. (Figure I). Both variables showed a significant association when vitamin D was compared with CT-BMD ($p < 0.001$). (Table II). A significant association was found between CT BMD and vitamin D levels, controlling for age, gender, obesity, urban residence, diabetes status (diabetics and non-diabetics), and hypertension status (hypertensives and non-hypertensives). No significant association was observed between BMI in normal weight (p=0.402) and overweight (p=0.063) or rural residence (p=0.069). (Table III).

Table I. Demographic and baseline profile of patients

Variable	N (%)	Mean ± S.D.
Age (years)		55.05±10.54
18-40	12 (12.0)	
41-70	88 (88.0)	
Gender		
Male	31 (31.0)	
Female	69 (69.0)	
BMI (kg/m²)		26.17±3.20
Normal weight	29 (29.0)	
Overweight	60 (60.0)	
Obese	11 (11.0)	
Residence		
Urban	46 (46.0)	
Rural	54 (54.0)	
Diabetics	39 (39.0)	
Hypertensives	31 (31.0)	

Figure 1: Distribution of Vitamin D levels and CT-BMD

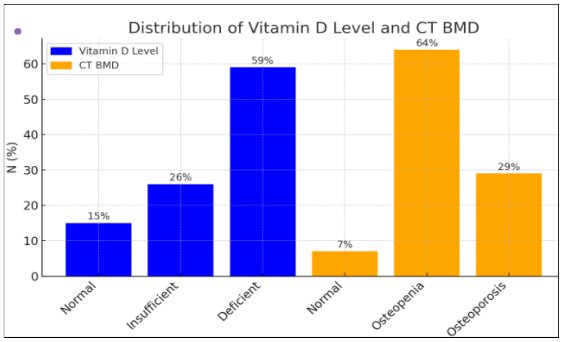

Table II. Association of CT BMD levels and vitamin D levels

CT BMD levels	Vitamin D levels			Total	Test of sig.
	Normal	Insufficient	Deficient		
Normal	3 (20 %)	3 (11.5%)	1 (1.7%)	7 (7%)	χ^2=28 .28, d.f.=4 , p<0.0 01
Osteopenia	1 (6.7 %)	17 (65.4%)	46 (78%)	64 (64 %)	
Osteoporosis	11 (73.3 %)	6 (23.1%)	12 (20.3 %)	29 (29 %)	
Total	15 (100 %)	26 (100%)	59 (100 %)	100 (100 %)	

Table III. Association of CT BMD levels and vitamin D levels with demographic and baseline variables

Variable	CT BMD levels	Vitamin D levels			Test of sig.
		Normal	Insufficient	Deficient	
Age (years)					
18-40	Normal	0 (0.0)	0 (0.0)	0 (0.0)	χ^2=0.5 3, d.f.=4 , p=0.7 66
	Osteopenia	1 (33.3)	2 (50.0)	3 (60.0)	
	Osteoporosis	2 (66.7)	2 (50.0)	2 (40.0)	
41-70	Normal	3 (25.0)	3 (13.6)	1 (1.9)	χ^2=29. 98, d.f.=4 , **p<0.0 01**
	Osteopenia	0 (0.0)	15 (68.2)	43 (79.6)	
	Osteoporosis	9 (75.0)	4 (18.2)	10 (18.5)	
Gender					
Male	Normal	1 (33.3)	1 (8.3)	0 (0.0)	χ^2=9.7 3, d.f.=4 ,
	Osteopenia	0 (0.0)	9 (75.0)	13 (81.3)	

	Osteoporosis	2 (66.7)	2 (16.7)	3 (18.8)	**p=0.045**
Female	Normal	2 (16.7)	2 (14.3)	1 (2.3)	χ^2=19.78, d.f.=4, **p=0.001**
	Osteopenia	1 (8.3)	8 (57.1)	33 (76.7)	
	Osteoporosis	9 (75.0)	4 (28.6)	9 (20.9)	
BMI (kg/m²)					
Normal weight	Normal	1 (25.0)	0 (0.0)	1 (5.3)	χ^2=4.02, d.f.=4, p=0.402
	Osteopenia	1 (25.0)	4 (66.7)	13 (68.4)	
	Osteoporosis	2 (50.0)	2 (33.3)	5 (26.3)	
Overweight	Normal	2 (25.0)	2 (12.5)	0 (0.0)	χ^2=8.94, d.f.=4, p=0.063
	Osteopenia	0 (0.0)	10 (62.5)	30 (83.3)	
	Osteoporosis	6 (75.0)	4 (25.0)	6 (16.7)	
Obese	Normal	0 (0.0)	1 (25.0)	0 (0.0)	χ^2=22.50, d.f.=4, **p<0.001**
	Osteopenia	0 (0.0)	3 (75.0)	3 (75.0)	
	Osteoporosis	3 (100.0)	0 (0.0)	1 (25.0)	
Residence					
Urban	Normal	1 (25.0)	1 (9.1)	1 (3.2)	χ^2=23.36, d.f.=4, **p<0.001**
	Osteopenia	0 (0.0)	8 (72.7)	21 (67.7)	
	Osteoporosis	3 (75.0)	2 (18.2)	9 (29.0)	
Rural	Normal	2 (18.2)	2 (13.3)	0 (0.0)	χ^2=8.68, d.f.=4, p=0.069
	Osteopenia	1 (9.1)	9 (60.0)	25 (89.3)	
	Osteoporosis	8 (72.7)	4 (26.7)	3 (10.7)	
Diabetes					
Yes	Normal	2 (66.7)	1 (12.5)	1 (3.6)	χ^2=13.44, d.f.=4, **p=0.009**
	Osteopenia	0 (0.0)	6 (75.0)	22 (78.6)	
	Osteoporosis	1 (33.3)	1 (12.5)	5 (17.9)	
No	Normal	1 (8.3)	2 (11.1)	0 (0.0)	χ^2=19.57, d.f.=4, **p=0.001**
	Osteopenia	1 (8.3)	11 (61.1)	24 (77.4)	
	Osteoporosis	10 (83.3)	5 (27.8)	7 (22.6)	
Hypertension					
Yes	Normal	1 (12.5)	0 (0.0)	0 (0.0)	χ^2=14.43, d.f.=4
	Osteopenia	1 (12.5)	6 (60.0)	12 (92.3)	, **p=0.006**
	Osteoporosis	6 (75.0)	4 (40.0)	1 (7.7)	
No	Normal	2 (28.6)	3 (18.8)	1 (2.2)	χ^2=19.15, d.f.=4, **p=0.001**
	Osteopenia	0 (0.0)	11 (68.8)	34 (73.9)	
	Osteoporosis	5 (71.4)	2 (12.5)	11 (23.9)	

4. DISCUSSION

DEXA-BMD testing is the global benchmark for evaluating the risk of fragility fractures. The U.S. National Osteoporosis Foundation advocates for pharmacological intervention in postmenopausal women and men over 50 with osteopenic bone mineral density.[14] Nonetheless, certain evidence indicates that limits persist in the clinical application of DXA. Research indicates that over 80% of patients with osteoporosis-associated fragility fractures do not have similar bone mineral density (BMD) values. Moreover, DXA analysis is based on two-dimensional images and is unable to differentiate between cancellous and cortical bone. Moreover, age-associated degenerative alterations, including the formation of osteophytes, increased soft tissue density, and atherosclerosis, may result in inaccurately normal or elevated BMD levels. [15]

The mean age of the patients was 55.05±10.54 years, with 31% of the patients being male. Most of the patients were overweight. In a study on the prevalence of musculoskeletal pain, the mean age was approximately 51 years, with a higher prevalence among females. About 1/3 were associated with low back pain.[16] Patients' mean vitamin D level was 22.22±10.35, with 59% as deficient. A meta-analysis of RCTs conducted in 308 countries reported deficient vitamin levels in 48% of patients.[17] Consistent with our study, data from 26,750 Pakistani individuals reported a deficiency in 56% of patients.[18] The

major factors related to this deficiency were older age, female gender, being overweight, and the presence of chronic diseases.[19]

The mean CT BMD was -1.85±1.14, with 29.0% with osteoporosis. Most patients with osteoporosis were found to be related to vitamin D deficiency, indicating a significant association. However, about 11% of patients had normal vitamin D levels. In a study by Yousaf et al., the mean T-scores for CT-BMD were -2.4 ± 1.4 SD. There was a high incidence, as this study was done in post-menopausal women.[20] A study by Sadat et al. reported a significant influence of vitamin D on BMD. Consistent with our study, the prevalence of osteopenia is 11% of patients with normal vitamin D levels in Saudi Arabian individuals.[11] So, other reasons for osteoporosis, like chronic co-morbid conditions, should also be considered. In a study of patients with Inflammatory Bowel Disease, osteoporosis was found in 60% of patients with CT-BMD. [21]

The limitation of our study was the lack of proper documentation regarding chronic co-morbid conditions, as patients were referred to the radiology department. The data was not documented based on menopausal status. The study was conducted at a single center with a smaller sample size. A comparison of CT-BMD with vitamin D levels, stratified by co-morbid conditions and menopausal status, is warranted. An RCT can be planned pre- and post-intervention to determine vitamin D level and its effect on BMD, which can be very rewarding.

5. CONCLUSION

Our study concluded that CT BMD is significantly associated with vitamin D levels. Most patients with osteopenia and osteoporosis have had deficient vitamin D levels. However, osteoporosis can be associated with normal levels of vitamin D.

CONFLICT OF INTEREST: The authors had no conflict of interest.

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