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MORPHOMETRIC EVALUATION OF LUMBAR SPINE AND ITS CORRELATION WITH BONE MINERAL DENSITY, SERUM VITAMIN D & SERUM CALCIUM IN PRE-MENOPAUSAL AND POST-MENOPAUSAL WOMEN

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Abstract

Background: Morphometry of vertebra is a mirror to osseous strength which is dependent on BMD which is in turn determined by the calcium and vitamin D status of body. Thus, the aim of this study was to determine morphometry and BMD of lumbar spine and correlate them with serum levels of calcium and vitamin D.

Materials and methods: This study was conducted with 200 healthy women of 25-64 years age in the Department of Anatomy and Department of Orthopedics, Rama Medical College and Research Center, Rama University, Mandhana, Kanpur Uttar Pradesh. The BMD of lumbar spine was measure using DEXA while the morphometry was evaluated with MRI. Serum levels of calcium and vitamin D were analyzed with standard kit-based methods.

Result: BMD of lumbar spine, serum calcium and vitamin D were significantly low in post-menopausal women. Morphometry of lumbar spine (Ha, Hm, Hp, AP and WI) significantly reduced with the reduction in BMD. There was significant association of age and menstrual status with BMD, serum calcium and vitamin D. Lumbar spine BMD showed significant correlation with serum calcium and vitamin D in both pre and post-menopausal women.

Conclusion: Alteration in BMD affects the morphometry of vertebral spine, thus increasing the risk of osteopenia and osteoporosis. Early diagnosis and preventive measures are necessary to maintain the normal bone mass.

Keywords: Calcium, Vitamin, Osteoporosis, Bone mineral density, Vertebral spine

Introduction

Bone mineral density (BMD) is a key determinant of osteoporotic fracture risk. The gold standard to measure BMD is DEXA (Dual Energy X-ray Absorptiometry). According to WHO (World Health Organization), BMD is expressed in terms of T-score, which is the measure of variation in BMD value of an individual with respect to normal young subjects. It is expressed as standard deviation of normal young subjects [1].

In osteoporosis, there is decline in bone mass and impairment of micro-architecture of osteoid tissues that increase bone fragility and susceptibility to fracture [2]. Low BMD affects the entire skeleton of human body, however the vertebral spines which are the primary load bearing region are most severely affected. The affected spine exhibits decreased horizontal trabecular cross-braces in cancellous bones of vertebral bodies, resulting in compromise of osseous strength which increases considerable risk of morbidity and mortality [3]. Depending upon the body need, the vertebrae experience continuous remodeling throughout the life time of an individual [4].

Minerals like calcium and vitamin like vitamin D are associated with BMD [5]. Deficiency of vitamin D leads to low serum calcium level that causes secondary increase in PTH (parathyroid hormones). PTH increases resorption causing increase in bone turnover, decrease in bone mass and increase in risk of osteoporosis development [6]. Several studies have been conducted in past to evaluate association of vitamin D and BMD. However, the findings observed are controversial. Significant association was observed in the young participants [7] and post-menopausal women [8, 9] while no association was reported in the studies conducted in Singapore [10], Bangladesh [11] and India [12] among the patients with low BMD.

Since past two decades osteoporosis has become global attention because of its silent nature and wide spread effect. Individuals are not aware of the decline in their bone health until osteoporosis and fracture since there is no evident pain sensation due to bone loss [13]. The high prevalence of this silent disease is attributed to life style including low physical activity, decreased intake of calcium and vitamin D [14].

Therefore, this study was conducted to evaluate the relationship between bone mineral density, calcium and vitamin D level which may be useful in diagnosis of altered bone mass so that timely intervention with supplementation of calcium and vitamin D can be initiated rather than opting for anti-bone resorptive therapy.

Materials and methods

This cross-sectional study was conducted in the department of Anatomy and Department of Orthopedics, Rama Medical College and Research Center, Rama University, Mandhana ,Kanpur, Uttar pradesh, with inclusion of 200 healthy women of age 25-64 years. The participants were categorized into 4 groups depending upon the age as follows:

- Group 1: 25-34 years
- Group 2:35-44 years
- Group 3: 45-54 years
- Group 4: 55-64 years

Based on menstrual status, the participants were categorized as:premenopausal women and post-menopausal women.

Inclusion criteria

- Healthy women of age 25-64 years
- Women without bone deformities
- Women willing to participate

Exclusion criteria

- Patients with history of fractures due to minor trauma or osteoporosis
- Patients with metabolic bone diseases, malignancy, renal failure, thyroid and parathyroid disorders
- Patients with hepatic illness, psychiatric illness, terminal illness and severe dementia
- Patients receiving hormone therapy, dietary supplements and ovarian surgery
- Patients under anticonvulsants, glucocorticoids, diuretics and thyroid medication

After obtaining ethical clearance from the institute, this study was commenced. Details of the patients like age, menstrual status, postmenopausal duration, physical activity, dietary habits, any medication etc were noted. Blood sample was collected by vein puncture method following all the precautions. The sample was centrifuged and clear serum was collected. Serum sample was stored at -20°C till analysis.

Serum levels of vitamin D and calcium were analysed using standard kit-based methods. Bone density measurement was carried out using DEXA (Dual Energy X-ray Absorptiometry) scan. WIPRO GE DPX – NT was used for this purpose. BMD values were expressed in terms of T-score. T score is a difference between BMD of individual patients and mean results of young adult population expressed as units of young population standard deviation.

According to WHO, T score ≤-2.5 SD is considered a case of osteoporosis, T score ≥-1 SD is considered normal and T score between -1 to > -2.5 SD is considered osteopenia. The morphometry of lumbar spine was evaluated with MRI. The morphometric parameters evaluated for lumbar spine (L_1 - L_4) included anterior height (Ha), middle height (Hm), posterior height (Hp), antero-posterior dimension (AP) and wedge index (WI).

Based on vitamin D levels, the cutoff points established were:

- Vitamin D deficiency: <12 ng/mL
- Vitamin D insufficiency: 12-30 ng/mL
- Vitamin D sufficiency (normal): >30 ng/mL

For serum calcium, the cutoff values established were:

- Hypocalcemia: <9 mg/dL
- Normal: 9-11 mg/dL
- Hypercalcemia: >11 mg/dL

Statistical analysis

It was done using SPSS program. The comparative analysis was done using students' t-test and ANOVA while correlation was determined by Pearson's correlation coefficient (r). The association of age and menstrual status with BMD, serum calcium and vitamin D was determined with chi square test. P value less than 0.05 indicated statistical significance.

Results:

Table 1: Comparison of serum level of vitamin D, calcium and spine BMD in the study participants

Group	Vitamin D (ng/mL) (Mean±SD)	Calcium (mg/dL) (Mean±SD)	Spine BMD (T score) (Mean±SD)
Premenopausal (N=90)	28 ± 5.79	10.6 ± 1.71	-1.77 ± 0.16
Postmenopausal (N=110)	12.9 ± 3.48	8.2 ± 1.25	-2.91 ± 0.18
P	0.001**	<0.007**	<0.004**

**:P<0.01→Statistical significance

Table 2: Morphometric measurements of lumbar spine

Parameters	Mean ± SD
Ha (Anterior height in mm)	27.4 ± 0.86
Hm (Middle height in mm)	24.8 ± 1.12
Hp (Posterior height in mm)	25.9 ± 0.75

AP (Anteroposterior dimension in mm)	28.3 ± 0.59
WI (Wedge index)	1.1 ± 0.03

Table 3: Comparative evaluation of lumbar spine morphometry in three different groups (Normal, osteopenia, osteoporosis)(Mean±SD)

Spine parameter	Normal (N=37)	Osteopenia (N=65)	Osteoporosis (N=98)	p
Ha (Anterior height in mm)	26.4 ± 0.62	25.1 ± 0.81	21.5 ± 0.77	0.001**
Hm (Middle height in mm)	25.8 ± 0.83	24.3 ± 0.68	21.6 ± 0.92	0.001**
Hp (Posterior height in mm)	26.7 ± 0.73	24.9 ± 0.85	23.8 ± 1.01	0.003**
AP (Anteroposterior dimension)	27.8 ± 0.49	26.5 ± 0.58	25.6 ± 0.31	0.005**
WI (Wedge index)	1.08 ± 0.03	0.95 ± 0.06	0.91 0.01	0.009**

**: P<0.01→Statistical significance

Table 4: Comparative evaluation of serum calcium and vitamin D in three groups in pre-menopausal and post-menopausal women (Mean±SD)

Parameter	Group	Pre-menopausal(N=90)	Post-menopausal(N=110)	P
Calcium (mg/dL)	Normal	9.8 ± 0.24	9.1 ± 0.66	0.021*
	Osteopenia	8.2 ± 1.12	7.3 ± 0.91	0.003**
	Osteoporosis	6.5 ± 0.38	6.3 ± 0.54	0.317^{NS}
Vitamin D (ng/mL)	Normal	38.2 ± 2.61	20.6 ± 1.98	0.001**
	Osteopenia	26.3 ± 3.11	11.8 ± 0.99	0.001**
	Osteoporosis	17.5 ± 1.96	8.7 ± 1.01	0.001**

*:P<0.05→Statistical significance;**:P<0.01→Statistical significance; P>0.05→Non significant(NS)

Table 5: Correlation of lumbar spine BMD with serum calcium and vitamin in premenopausal and post-menopausal women

Parameter	Pre-menopausal (N=90)		Post-menopausal (N=110)	
	R	p	r	p
Spine BMD-Ca	0.61 **	0.001**	0.58 **	0.001**
Spine BMD-Vitamin D	0.85 **	0.001**	0.66 *	0.001**

**: P<0.01→Statistical significance

Table 6: Status of serum calcium, vitamin D and lumbar spine BMD based on age

Parameter	Age (N)	Categories		
		Normal(N/%)	Insufficient(N/%)	Deficient(N/%)
Vitamin D	25-34 years (N=38)	11 (28.9%)	14 (36.8%)	13 (34.2%)
	35-44 years (N=49)	15 (30.6%)	18 (36.7%)	16 (32.6%)
	45-54 years (N=63)	20 (31.7%)	23 (36.5%)	20 (31.7%)
	55-64 years (N=50)	15 (30%)	19 (38%)	16 (32%)
	χ^2	0.135		

	p	0.517^{NS}		
Calcium	**Age (N)**	**Normal (N/%)**	**Hypocalcemia (N/%)**	**Hypercalcemia (N/%)**
	25-34 years (N=38)	12 (31.6%)	17 (44.7%)	9 (23.7%)
	35-44 years (N=49)	17 (34.7%)	21 (42.8%)	11 (22.4%)
	45-54 years (N=63)	20 (31.7%)	28 (44.4%)	15 (23.8%)
	55-64 years (N=50)	16 (32%)	22 (44%)	12 (24%)
	χ^2	0.151		
	p	0.445^{NS}		
BMD	**Age (N)**	**Normal (N/%)**	**Osteopenia (N/%)**	**Osteoporosis (N/%)**
	25-34 years (N=38)	7 (18.4%)	12 (31.6%)	19 (50%)
	35-44 years (N=49)	9 (18.7%)	17 (34.7%)	23 (46.9%)
	45-54 years (N=63)	12 (19%)	20 (31.7%)	31 (49.2%)
	55-64 years (N=50)	9 (18%)	16 32%)	25 (50%)
	χ^2	0.175		
	p	0.438^{NS}		

p>0.05: Non Significant (NS)

Table 7: Status of serum calcium, vitamin D andlumbar spine BMD based on menstrual status

Parameter	**Status**	**Categories**		
Vitamin D		**Normal (N=61)**	**Insufficient (N=74)**	**Deficient (N=65)**
	Pre-menopausal (N=90)	41 (45.5%)	36 (40%)	13 (14.4%)
	Post-menopausal (N=110)	20 (18.1%)	38 (34.5%)	52 (47.4%)
	χ^2	27.28		
	p	0.001**		
Calcium	**Status**	**Normal (N=65)**	**Hypocalcemia (N=88)**	**Hypercalcemia (N=47)**
	Pre-menopausal (N=90)	36 (40%)	21 (23.3%)	33 (36.7%)
	Post-menopausal (N=110)	29 (26.4%)	67 (60.9%)	14 (12.7%)
	χ^2	30.78		
	p	0.001**		
BMD	**Status**	**Normal (N=37)**	**Osteopenia (N=65)**	**Osteoporosis (N=98)**
	Pre-menopausal (N=90)	26 (28.9%)	29 (32.2%)	35 (38.9%)
	Post-menopausal (N=110)	11 (10%)	36 (32.7%)	63 (57.3%)
	χ^2	12.96		
	p	0.035*		

*:P<0.05→Statistical significance; **:P<0.01→Statistical significance

In this study, BMD in lumbar spine, serum levels of calcium and vitamin D were found to be significantly low in the post-menopausal women when compared with pre-menopausal women (table 1). The morphometric parameters of lumbar spine evaluated were anterior height (Ha),

middle height (Hm), posterior height (Hp), anteroposterior diameter (AP) and wedge index (WI). (table 2)

Based on BMD expressed as T-score, the participants were divided into three groups namely normal, osteopenic and osteoporotic. 18.5%, 32.5% and 49% of participants were found to be normal, osteopenic and osteoporotic. The morphometrical parameters of lumbar spine were compared among normal, osteopenic and osteoporotic individuals. There was significant difference in the mean values of the parameters among these three groups (table 3).

In table 4 comparative evaluation of serum calcium and vitamin D in premenopausal and post-menopausal women based on status of BMD is shown. Irrespective of BMD, post-menopausal women had significantly low levels of serum calcium and vitamin D in all the three groups (normal, osteopenia and osteoporosis).

The BMD of lumbar spine significantly correlated with serum calcium and vitamin D levels in both pre-menopausal and post-menopausal women as shown in table 5.

In table 6, the status of BMD, serum calcium and vitamin D was presented based on age. Serum calcium, vitamin D and BMD decreased with the increase in age but the association was not significant statistically.

Similarly, table 7 represented the status of BMD, serum calcium and vitamin D based on the menstrual status. It was observed that there was significant association of pre-menopausal and post-menopausal status with BMD, calcium and vitamin D. The levels of these parameters were significantly low in post-menopausal women.

Discussion

Both vitamin D and calcium are essential components required for mineralization of bone. Deficiency of these essential elements leads to loss of bone mass and impairment in the micro and macro anatomy of the affected bone. Compared to males, females are more prone to osteoporotic fractures which is attributed to estrogen deficiency in their later stage of life. Hence, in this study we evaluated bone mineral density of lumbar spine and correlated it with the circulating levels of calcium and vitamin D in pre-menopausal and post-menopausal women.

In this study, significantly low levels of BMD, serum calcium and vitamin D were observed in post-menopausal women. Several studies have documented low BMD in the individuals with vitamin D deficiency. Sadat Ali *etal* reported that patients with vitamin D insufficiency have low bone mass while the patients with vitamin D deficiency exhibited BMD ranging from osteopenic to osteoporotic status [15].

Vitamin D is a hypercalcemic hormone and it maintains serum calcium level by increasing intestinal calcium absorption, renal calcium reabsorption and stimulating osteoclastic bone resorption in presence of PTH hormone [8]. As per Beg M*etal*[16] the prevalence of vitamin D deficiency in post-menopausal women is 68.24% while that of vitamin D insufficiency is 20.27%.

In the study of Kamineni V*etal*[17], BMD of lumbar spine was 1.2 ± 0.18 in normal and 0.81 ± 0.13 in osteoporotic patients and difference was statistically significant which was similar to our study. In post-menopausal women due to deficiency of estrogen and age related reduced osteoblastic function, calcium absorption and diminished ability of vitamin D synthesis, the BMD decrease significantly leading to osteoporosis.

In the present study, it was found that with the decrease in BMD, there is significant decrease in Ha, Hm, Hp, AP and WI of lumbar spine. Our results were in line with that of Twomey and Taylor *etal*[18] who showed that reduction in BMD weakens horizontal trabeculae ultimately increasing concavity of vertebra since the vertebral discs remain firmer compared to unsupported osteoporotic endplates of vertebra. The osteoporotic spine due to increased porosity of endplates, alters the nutritional pathway of vertebral discs, thereby resulting in the nutritional compensation from the adjoining vertebra with reduction in BMD [19, 20].

In this study, serum levels of calcium and vitamin D decreased significantly with the reduction in BMD in both pre-menopausal and post-menopausal women. The correlation of BMD with calcium and vitamin D was statistically significant. The result of present study was in agreement with the previous studies of Bischoff FHA *etal*[21] and RossouliA *etal*22]. Similarly, other studies done by Sadat Ali *etal*[15] in Saudi Arabia,BenerA *etal*[23] in Qatar and Napoli N *etal*[9] in Italy also demonstrated positive association of vitamin D with BMD. However, some contradictory reports are also available in literature. Studies of Chandran M *etal* in Singapore [24] and Man PW*etal*[25] in China showed no association of BMD with vitamin D. Similarly, a study conducted in India by Kota S *etal*[12] did not find any direct association of vitamin D with BMD even though all the participants included in their study were osteopenic and osteoporotic with low BMD. Other two studies conducted in post-menopausalwomen by LabroniciPJ *etal*[26] and Ahmed AS *etal*[27] also documented similar findings.

Study of Ismail Tuwan TS*etal*[28] showed significant positive correlation of hip BMD with vitamin D but not with lumbar BMD. As per the authors bone comprises cortical and trabecular bone mass, the volume of which differ based on site. The lumbar spines mostly comprise trabecular bone surrounded by a thin layer of cortical bone. The stability of trabecular bone is relative more than that of cortical bone in presence of high PTH which makes lumber spine BMD less affected compared to hip BMD.

The association of BMD, calcium and vitamin D was evaluated based on age and menstrual status. There association was statistically significant in case of menstrual status. In India, prevalence of vitamin D deficiency is alarmingly high. In the present study, 47.4% of post-menopausal women were vitamin D deficient. In the study of Harinarayan CV *etal*[29], Kamineni V *etal*[17] and Lavanya Y *etal* [1], the incidences of vitamin D deficiency were respectively 70%, 78% and 75%. Similarly, 47%, 49%, 90% and 92% of post-menopausal women were reported to be vitamin D deficient in Thailand, Malaysia, Japan and South Korea respectively [30].

Conclusion

The present study demonstrates high prevalence of osteoporosis especially in post-menopausal women which is attributed to decreased bone mineral density, serum calcium and vitamin D levels. Both serum calcium and vitamin D are the important predictors of BMD. Therefore, routine examination of these parameters in women along with DEXA scan may help in early identification of risk of osteoporosis and associated fractures so that timely intervention in terms of calcium and vitamin D supplemented can be provided. This study may also be helpful in creating public awareness about the significance of calcium and vitamin D deficiency in bone health in the women especially post-menopausal women.

Conflict of interest: Nill

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