

Assessment of Bone Mineral Density Through Computed Tomography Scan Among Menopausal Women

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ABSTRACT

Background:

Low bone mineral density poses a significant health concern. As it may result in osteopenia and if left untreated it can lead to osteoporosis. This disease majorly affects menopausal women due to cessation of estrogen level. DEXA scans are a gold standard for measuring bone mineral density, but its unavailability, additional radiation dose, additional cost, and inaccurate measurement in patient with degenerative disease has become one of the major disadvantages. CT imaging that includes lumbar vertebrae addresses this by measuring the mean trabecular Hounsfield value, providing valuable information regarding the bone mineral density. This mean trabecular Hounsfield value can predict the patient with osteopenia and osteoporosis which can be helpful in treatment decisions and improving patient management.

Objective:

To assess the bone mineral density using mean trabecular Hounsfield value through CT scan among menopausal women.

Materials & Methods:

This was a prospective cross-sectional study was conducted at NIMS Hospital Jaipur, Rajasthan on 96 selected subjects for a period of 4 months from January 2026 to April 2026. The information was recorded on a self-designed data capture sheet. Data was analysed using Microsoft Excel 2021 and descriptive statistics.

Results:

The study included 96 menopausal women it was seen that there was high prevalence of low BMD. The prevalence of osteopenia (42.71%) was seen to be highest, followed by osteoporosis (38.54%) while least prevalence was seen of normal bone density (18.75%). The result showed significance correlation between mean trabecular HU value and BMD ($p < 0.001$). It was also noted that parameter like advancing age and post-menopausal duration were significantly related with reducing BMD ($p < 0.001$). The highest prevalence of osteoporosis was seen among menopausal women aged >70 years. The BMD was noted to be decreased with increasing standard deviation ($p < 0.01$).

Keywords: Bone mineral density, osteoporosis, osteopenia, mean trabecular Hounsfield unit, CT imaging, DEXA scan, lumbar vertebrae, menopausal women.

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INTRODUCTION

Bone mineral density is a decisive element to measure bone strength and to predict the occurrence of fracture.

[1] Osteoporosis is a disease that is characterized by

weakened bone density, reduced bone mass and deterioration of the microscopic bone structures (trabecular and cortical bone). [2] It is one of the most

common and prevalent disease among people, causing

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significant health concern, especially among postmenopausal women.^[3] As in postmenopausal women the cessation of ovarian function causes deficiency in estrogen level, which results in deterioration of bones faster with growing age.^[4]

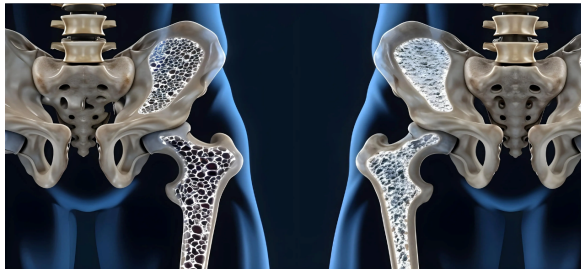


FIG. 1 Difference in osteoporotic and normal bone ^[20]
(First image is showing osteoporotic bone while second image showing normal bone)

Osteoporosis is a worldwide ailment, affecting millions of people, playing an instrumental role in morbidity, mortality and increasing healthcare burden.^{[4][5]} In India, it is reported that 42.5% women and 24.6% men above 50 years of age suffers from osteoporosis.^[6] Dual-energy x-ray absorptiometry (DEXA) is widely considered as the gold standard for diagnosing the osteoporosis and low bone mineral density.^[5] However, there are limitations of this imaging technique which includes limited availability, additional scan cost, additional radiation exposure.^[7] Even it has been reported that DEXA gives inaccurate measurement in degenerative spinal conditions.^[8]

Computed Tomography (CT), this imaging modality is used on routine basis for different types of pathology detection.^[9] There is a quantitative unit that represents the attenuation of x-rays through different part of the tissues, while showing their properties. this unit is called Hounsfield Unit expressed as HU.^[10] This unit is capable of estimating the tissue density of trabecular bone called as mean trabecular Hounsfield unit.^[11] Recent studies have shown significant correlation among T-score of DEXA scan and CT-derived mean trabecular hounsfield unit.^{[12][13]}

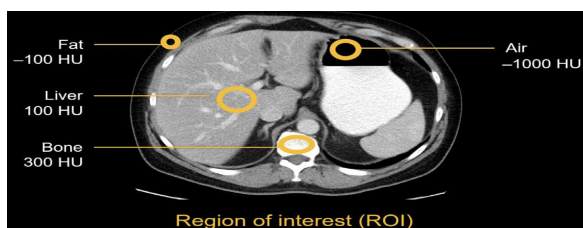


FIG. 2 Different tissue density showing different HU values ^[21]

This study aims to do assessment of BMD through CT-derived mean trabecular hounsfield unit among menopausal women. so, that early detection of this ‘Silent Diseases’ can be done and treatment becomes

manageable. This study also shows association between mean trabecular HU value with age and post-menopausal duration.

Materials and Methods

This study is prospective observational cross-sectional study, that was conducted in Department of Radio-Diagnosis in NIMS Hospital, Jaipur, Rajasthan. It was over 4 months of study period from January 2026 to April 2026. Study included 96 post-menopausal women aged above 45years of age, that are undergoing CT scans of abdomen, thorax, lower limb, spine that includes lumbar vertebrae. The study was conducted on Siemens Healthineers Somatom go. Top 128 slice (expandable) MDCT scanner. Slice thickness was reconstructed to 3mm for non-contrast images. With exposure factor ranging kvp: 120-140, mAs: 80-130.

Axial images were reconstructed to required slice thickness using bone window. L1 vertebrae was identified and ROI (region of interest) was placed at trabecular bone excluding cortex, basivertebral venous plexus, focal lesions, osteophytes to prevent the risk of deflection in Hounsfield unit. The mean trabecular HU is measured only for those who lies under standard deviation value and represented as mean \pm SD.

SD RANGE (HU)	INTERPRETATION
≤ 40 HU	Excellent and homogeneous
41-60 HU	Acceptable for normal people
61-80 HU	Acceptable for menopausal women
$>80-100$ HU	Questionable and requires replacement of ROI
>100 HU	Excluded

TABLE 1 SD Value Range with their interpretation ^{[14][15]}

The required mean trabecular HU were categorized into normal bone density, osteopenia, osteoporosis accordingly.

BONE STATUS	Trabecular Hounsfield Unit Threshold
Normal bone density	>150 HU
Osteopenia	110-150HU
Osteoporosis	<110 HU

TABLE 2 Trabecular HU threshold interpreting their bone status ^{[16][17][18][19]}

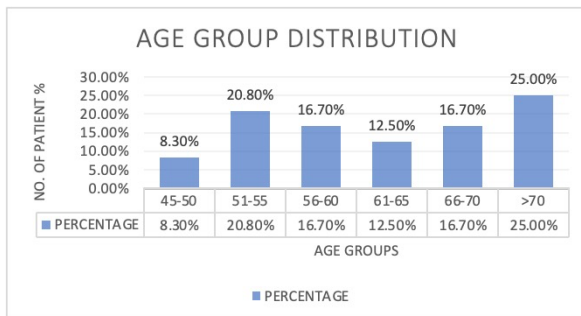
Statistical Analysis

Statistical analysis was conducted for the results using the IBM SPSS Statistics with data tabulation and management was performed under Microsoft Excel 2021. The analysis done using the Chi-square test showed ($p < 0.001$). While the Anova test showed ($p < 0.01$).

RESULTS

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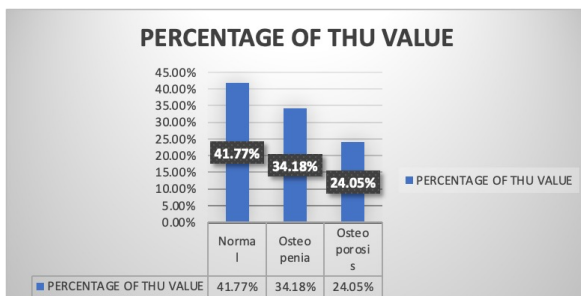
The study involving 96 menopausal women, aged above 45 years was conducted. The CT scans of these menopausal women were conducted for any other medical findings, which included lumbar vertebra. The age-wise distribution of these women showed majority of higher aged females. Among which the >70 years of age group consisted of 24 subjects making it the largest group. Followed by the women with age group of 51-55 years, with number of 20 subjects. The least number of participants were found in the age group of 45-50 with 8 subjects. This indicates that the study was skewed toward elderly aged menopausal women.



GRAPH 1 NO. OF PATIENTS WITH DIFFERENT AGE GROUPS

The highest patient count is in the >70 age group, followed closely by the 51-55 years age group.

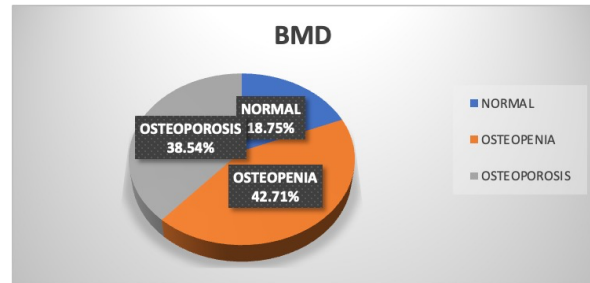
The 45-50 years age group has the lowest patient count. In the study it is analysed that the mean trabecular hounsfield unit showed consistent decline from normal bone density groups to osteoporotic groups. Post menopausal women with normal BMD had the highest mean HU value (~165HU), whereas the osteoporotic subjects had lowest (~95HU). The difference between both the values is statistically very significant ($p < 0.001$), which indicates that the mean trabecular HU derived through CT scan is strongly associated with BMD.



GRAPH 2 MEAN TRABECULAR HU COMPARED WITH BMD

As shown in pie graph, the women with normal BMD had highest mean THU value of ~165HU, and least THU was of osteoporotic post-menopausal women of ~95. Clearly indicating that mean THU value is strongly linked with BMD of post-menopausal women with significant $p < 0.001$.

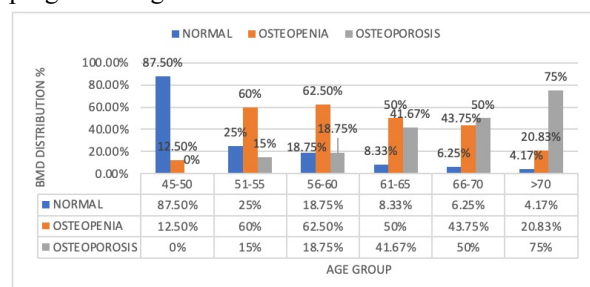
Assessment of BMD using CT scan mean trabecular hounsfield unit revealed that osteopenia was most common finding among the subjects with 41 subjects, followed by osteoporosis with 37 subjects, while the least number of subjects were having normal bone density with 18 subjects. This highlights a reduced bone mineral density among menopausal women in the study population.



GRAPH 3 PATIENT DISTRIBUTION WITH THEIR BMD

As shown in pie graph, maximum number of subjects were observed to be having Osteopenia, affecting 42.71% of patients. This was followed by osteoporosis with 38.54% of patients, and subjects with normal BMD were at least percentage of 18.75%.

When BMD was analysed with the different age groups it clearly showed a trend of declining bone mineral density with respect to increasing age. The age group of 45- 50 years had predominantly normal BMD with 7 out of total 8 subjects, and it was also seen that osteoporosis was absent from this age group. On the other hands the older age groups showed higher number of cases of osteoporosis. Age group of >70 years had highest number of osteoporotic cases with 18 subjects out of 24 total subjects. Normal bone density almost got negligible above 60years of age group. Indicating loss in bone mineral density with progressive age.



GRAPH 4 DISTRIBUTION OF BMD ACCORDING TO AGE GROUPS

As shown in bar graph, age group 45-50 years have maximum number of subjects with normal bone density with 7 out of 8 total subjects. While age group of >70 years have maximum number of subjects having osteoporosis with 18 out of 24 total subjects. As it is

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clearly seen that with increasing age the BMD is declining.

DISCUSSION

The present study represented significant association between mean trabecular hounsfield unit and BMD ($p < 0.001$). It demonstrated the high prevalence of low BMD among menopausal women as 80% of subjects were having low BMD. Among which 42.71% subjects were having osteopenia and 38.54% were having osteoporosis highlighting the importance of early detection of the disease.

Perry J. Pickhardt et al.^[22] reported in their study that vertebral trabecular HU values can reliably estimate the BMD through routine abdominal CT scans. Their study stated inverse relationship between HU value and prevalence of osteoporosis. Their results support our study which also shows a strong inverse correlation with strong statistical significance ($p < 0.001$) between mean trabecular HU and BMD.

The results highlighted the predominance of low BMD among elderly aged women with 75% of subjects affected with osteoporosis and 20.83% with osteopenia. While younger aged patients were not having osteoporosis, highlighting the role of advancing age in low BMD.

Study showed the inverse significant relation between BMD and post-menopausal duration ($p < 0.001$). Prevalence of low BMD was seen majorly above 10 years of post-menopausal duration.

Emanuel M. Messina et al.^[23] demonstrated in their study that increasing age and longer menopausal duration shows high significance with low HU values of CT scans. And our study has also mentioned this relation, stating that advancing age and postmenopausal duration are inversely related to BMD with significance ($p < 0.001$). The continuous decline in BMD in respect to advancing age in their study results supports our findings of osteoporosis higher prevalence among elderly age group (>70 years) subjects

There was a strong association noted between increasing SD value and decreasing BMD value ($p < 0.01$). Indicating that heterogeneity in trabecular bone increases with prevalence of osteoporosis.

These significant correlation and statistical significance highlight the role of CT derived mean trabecular HU importance in early detection and timely management of osteoporosis. It shows that CT derived HU value can be used as an opportunistic tool for indicating osteoporosis among menopausal women, without any additional cost and radiation exposure.

CONCLUSION

This study aim was to assess BMD through CT derived mean trabecular HU value among menopausal women. It is concluded through results that CT derived HU values can be used as an opportunistic tool in indicating low BMD diseases among menopausal women. Mean trabecular HU value is a reliable and effective method for BMD assessment. The study a strong significance between BMD and age, menopausal duration and SD value. So, the study supports the role of CT derived mean trabecular HU value as effective method in early diagnosis of osteoporosis among menopausal women.

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