Original Article

DOI: 10.7860/IJARS/2021/46826:2599

Radiology Section

Evaluation of Bone Mineral Density using Quantitative Computed Tomography in Pre- and Post-menopausal Women: A Retrospective Cross-sectional Study

SR RAGHU[1], T SACHIN[2], K SHANKARA[3], BR SHASHIKIRAN[4]

ABSTRACT

Introduction: Osteoporosis is increasingly becoming a public health concern especially in the ageing population. Fractures related to osteoporosis are an important cause for pain and disability. Most common methods used for measuring Bone Mineral Density (BMD) include Dual-energy X-ray Absorptiometry (DXA) and Quantitative Computed Tomography (QCT). There is a substantial increase in the number of patients undergoing a primary Computed Tomography (CT) study of the abdomen for various clinical reasons. Use of QCT for measurement of BMD helps to identify the high risk patients for osteoporotic fractures. This also reduces the need for any additional imaging, radiation exposure, cost or patient time.

Aim: To compare the BMD values between pre-menopausal and post-menopausal females using QCT.

Materials and Methods: This was a retrospective cross-sectional study. A total of 40 patients with 20 patients each in pre-menopausal and post-menopausal group who had undergone routine abdominal CT for various clinical indications unrelated to bone disorders were evaluated. Regions of Interest (ROIs) were measured on the axial images at T12 through L5 vertebrae at three locations, one over the trabecular part of vertebrae, one on the posterior paraspinal muscles and the third ROI over the subcutaneous fat. BMD was calculated by using phantom less QCT software of the Philips CT workstation. Both t-score and BMD values were automatically generated by the software. The thresholds for spinal trabecular BMD were <120 mg/cc for osteopenia (equivalent to a DXA T-score of -1.0 SD) and <80 mg/cc for osteoporosis (equivalent to a DXA T-score of -2.5 SD). Descriptive statistics were used to describe clinical demographics using range, means and Standard Deviation (mean±SD). Student's t-test was used to analyse comparisons between the study groups.

Results: For pre-menopausal women (n=20) in the age group of 30-45 years, the mean BMD observed was 157.01±27.36 mg/cc. For post-menopausal women (n=20) in the age group of >45 years, the mean BMD observed was 129.77±48.92 mg/cc. The mean t-score values for pre-menopausal and post-menopausal women were -0.67±0.88 and -1.57±1.58, respectively. Comparison of t-score ($p<0.05$) and BMD ($p<0.0001$) between the two groups was found to be statistically significant.

Conclusion: The BMD reduces considerably in the post-menopausal women in comparison to pre-menopausal women. Abdominal CT scans obtained for various clinical indications can be used to identify patients with reduced BMD and helps in early detection of osteoporosis.

Keywords: Dual x-ray absorptiometry, Fracture, Osteoporosis

INTRODUCTION

Osteoporosis is a common metabolic disorder which is defined as a skeletal disease and is characterised by compromised bone strength, predisposing a person to an increased risk for fracture [1]. Osteoporosis is widespread among Indian population with estimated more than 61 million affected individuals with 80% being females [2]. According to World Health Organisation (WHO), the normal BMD is defined as a t-score greater than or equal to -1.0 SD, a score between -1.0 to -2.4 SD indicates osteopenia and t-scores less than or equal to -2.5 SD suggests osteoporosis [3]. Quantification of BMD is used as the main method to diagnose osteoporosis. The quantification of BMD can be done by various imaging modalities which include DXA, single energy X-ray Absorptiometry, Peripheral DXA (PDXA), Radiographic Absorptiometry (RA), Dual Photon Absorptiometry (DPA), Single Photon Absorptiometry (SPA), Magnetic Resonance Imaging (MRI), QCT, and Ultrasound (US) [2]. The gold standard for measuring BMD is by DXA [4]. Osteoporosis in the presence of aortic calcification, vertebral fractures and degenerative changes increases the BMD value and shows false results [5]. In such instances, QCT scan is more sensitive and accurate.

BMD can be assessed with QCT which is a simple, non-invasive technique when access to DXA is restricted. QCT can be used to measure BMD at various sites such as lumbar spine, proximal femur, hip, and forearm. The ideal site most commonly used to measure BMD using QCT is the lumbar spine [6]. QCT mainly helps in determining the future fracture risk and also in evaluating the effectiveness of osteoporotic therapy [6].

Opportunistic evaluation of BMD can be done when CT scan of the abdomen and pelvis is indicated for other clinical reasons. In the present study, the correlation between the BMD measured by QCT was investigated in pre-menopausal and post-menopausal women.

MATERIALS AND METHODS

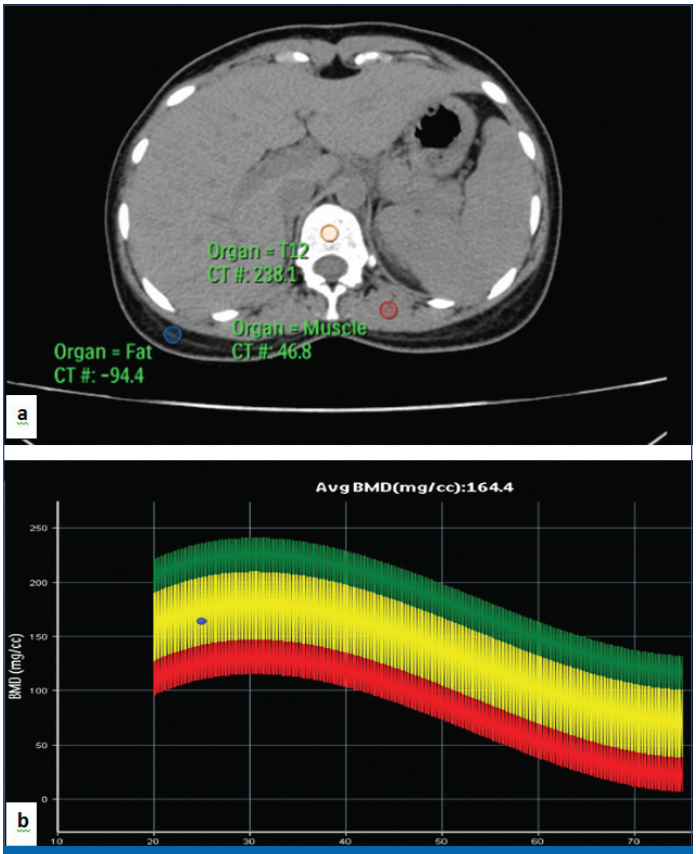
This was a retrospective cross-sectional study conducted in the Department of Radiology at Hassan Institute of Medical Sciences, Hassan, Karnataka, India. The study was approved by the Institutional Ethical Committee (IEC/HIMS/RR66). Patients who had undergone CT imaging at the institution during March-September 2018 were included. CT images were obtained and study analysis was performed between November-December 2018 for a period of two months. Patients were included based on their clinical records available at the time of study analysis.

Inclusion criteria: Pre-menopausal women between 30-45 years and post-menopausal women above 45 years who had undergone CT of the abdomen and pelvis (clinical indications unrelated to bone disorders) were included without additional imaging, radiation exposure, cost or patient time.

Exclusion criteria: Patients with known malignancy, pancreatitis, past surgery, ongoing hormonal or anti-osteoporotic therapy, scoliotic deformity, lesions in the vertebrae such as compression fractures, haemangiomas, osteomas, or any lytic/sclerotic lesions were excluded. Patients who had undergone chemotherapy or radiotherapy were also excluded.

Imaging Protocol

Non-contrast CT scan was performed using Philips MX 16-slice CT scanner for all patients (KVp=120, mAs=250, slice thickness of 2-3 mm). T12 to L5 vertebrae were selected for assessment. The CT sections for assessment of BMD were positioned parallel to vertebral end plates at the level of transverse processes. ROIs were measured on the axial images at T12 through L5 vertebrae at three locations, one over the trabecular part of vertebrae, one on the posterior paraspinal muscles and the third ROI over the subcutaneous fat [Table/Fig-1]. Care was taken not to include cortical bone or osteophytes. BMD was calculated by using phantom less QCT software of the Philips IntelliSpace CT workstation. Both t-score and BMD values were automatically generated by the software.



[Table/Fig-1]: (a) Three Regions Of Interest (ROIs) were placed on the axial images at T12 through L5 vertebrae, one over the trabecular part of vertebrae (orange circle), one on the posterior paraspinal muscles (red circle) and the other over the subcutaneous fat (blue circle); (b) Software generated QCT with BMD values.

Diagnostic Criteria

Patients were categorised as having osteoporosis based on the diagnostic criteria's given by the WHO [3] and International Society for Clinical Densitometry in 2007 [6]. Normal BMD is defined as a t-score >-1.0 SD, a score between -1.0 to -2.4 SD indicates osteopenia and t-scores <-2.5 SD suggests osteoporosis [3]. The thresholds for spinal trabecular BMD were <120 mg/cc for osteopenia (equivalent to a DXA T-score of -1.0 SD) and <80 mg/cc for osteoporosis (equivalent to a DXA T-score of -2.5 SD) [7].

STATISTICAL ANALYSIS

Statistical analysis was performed by using the software Statistical Package for the Social Sciences (SPSS) version 17.0. Descriptive statistics were used to describe clinical demographics using range, mean and SD (mean±SD). Student's t-test was used to analyse comparisons between the study groups. A difference with a p-value <0.05 was considered statistically significant.

RESULTS

A total of 40 female patients were included in the study. Twenty pre-menopausal patients with mean age of 37.8±4.6 years (range between 30-45 years) and 20 post-menopausal patients with mean age of 54.15±7.2 years (range between 45-70 years). Plain CT scan of the abdomen and pelvis was performed for various clinical indications as given in [Table/Fig-2].

Clinical indications	Number (n=40)
Hepato-biliary pathology	5 (12.5%)
Appendicitis	7 (17.5%)
Intestinal obstruction	3 (7.5%)
Ureteric colic	14 (35%)
Lower abdominal pain	8 (20%)
Inflammatory bowel disease	2 (5%)
Abdominal trauma	1 (2.5%)

[Table/Fig-2]: CT scan of the abdomen and pelvis performed for various clinical indications.

For pre-menopausal women (n=20) in the age group of 30-45 years, the mean BMD value observed was 157.01±27.36 mg/cc and mean t-score of -0.67±0.88 [Table/Fig-3]. The BMD was within normal limits for 19 patients (95%) and one patient (5%) was found to be osteopenic with BMD value of 111.1 mg/cc.

	Pre-menopausal (n=20)	Post-menopausal (n=20)
Mean age (years)	37.8±4.6	54.15±7.2
Mean t-score	-0.67±0.88	-1.57±1.58
Mean BMD value (mg/cc)	157.01±27.36	129.77±48.92
Normal BMD	19 (95%)	13 (65%)
Osteoporosis	0	4 (20%)
Osteopenia	1 (5%)	3 (15%)

[Table/Fig-3]: Comparison of mean age, t-score and BMD value between study groups.

For post-menopausal women (n=20) in the age group of 45-70 years, the mean BMD observed was 129.77±48.92 mg/cc and the mean t-score of -1.57±1.58 [Table/Fig-3]. The mean BMD value was above the normal threshold value of 120 mg/cc. Based on BMD values, four patients (20%) were categorised as osteoporotic and three patients (15%) were osteopenic in post-menopausal group. The BMD values for the four osteoporotic patients were 70.1 mg/cc, 69.7 mg/cc, 59.5 mg/cc and 72.5 mg/cc. The BMD values for the three osteopenic patients were 108.5 mg/cc, 104.1 mg/cc and 91.7 mg/cc. Only one patient in the pre-menopausal group was osteopenic (5%) with BMD value of 99.5 mg/cc. Comparison of t-score and BMD between the two groups was statistically significant as depicted in [Table/Fig-4,5].

Difference	0.900
Standard error	0.401
95% CI	0.0875 to 1.7125
t-statistics	2.242
DF	38
Significance level	p-value=0.0309 (p<0.05)

[Table/Fig-4]: Comparison of t-scores between pre-menopausal and post-menopausal patients.

Difference	102.86
Standard error	6.329
95% CI	90.0476 to 115.67
t-statistics	16.252
DF (degrees of freedom)	38
Significance level	p<0.0001

[Table/Fig-5]: Comparison of BMD values between pre-menopausal and post-menopausal patients.

DISCUSSION

Osteoporosis is characterised by decrease in the bone mass and microarchitectural deterioration of bone tissue, leading to increased bone fragility and fracture risk. It is mainly described as the disruption of the equilibrium between bone formation and bone resorption [8]. DXA and QCT are the most commonly used imaging techniques for BMD measurement [9]. The major disadvantage of DXA scan is that it does not differentiate between cortical and trabecular bone. Osteoporosis in the presence of aortic calcification, vertebral fractures and degenerative changes which typically increase the BMD value makes DXA less accurate. It is also less sensitive in presence of extreme obesity or low Body Mass Index (BMI). In such cases, QCT is found to be more sensitive [5]. BMD can be assessed with QCT which is a simple and non-invasive technique. However, usage of QCT for only diagnosis of osteoporosis is associated with significantly higher radiation dose [10]. The use of QCT for detection of osteoporosis remains underutilised. Various sites used for measurement of BMD include bones of axial and appendicular skeleton including the spine, proximal femur, and forearm. The ideal site most commonly used to measure BMD using QCT is the lumbar spine [6]. QCT can also be used to evaluate the effectiveness of osteoporotic therapy [6]. Similar studies combining standard CT imaging and QCT simultaneously for BMD measurement have been performed at the lumbar spine [11-14]. QCT provides a volumetric BMD measure of the trabecular vertebral bone in isolation which is an added advantage of superior sensitivity due to the higher turnover rate of trabecular bone [15].

The BMD values gradually decrease in the post-menopausal group compared to pre-menopausal group as observed in present study. A recent study showed complex relationship between age and BMD with accelerated bone loss in perimenopausal age group [2]. Increased risk of osteoporotic fractures was seen in post-menopausal women with significant reduction in the BMD [16]. CT scan of the abdomen and pelvis are performed in large numbers for various clinical indications in patients who are at potential risk of osteoporosis. An effort can be made to screen these patients without additional radiation dose. The present study mainly includes patients from South-Indian population. No previous study with the use of QCT for diagnosis of osteoporosis has been conducted involving South-Indian population. With increasing co-morbidities and perimenopausal risk factors for osteoporosis, concurrent screening for BMD in patients undergoing CT of the abdomen helps in early treatment to reduce fracture risk.

Limitation(s)

Present study included patients with unknown risk factors (undiagnosed metabolic diseases like thyroid disorders or Vitamin D deficiency) and doesn't completely represent healthy population. Further studies with a larger female population with known risk factors are required to substantiate the above results.

CONCLUSION(S)

Despite increase in the fracture risk statistics, osteoporosis testing with the use of DXA or QCT remains underused. The post-menopausal patients are at higher risk of osteoporosis compared to pre-menopausal women. The present study emphasises on the use of QCT for screening of post-menopausal women for osteoporosis who are subjected to CT of the abdomen for various clinical indications.

REFERENCES

[1] Ward RJ, Roberts CC, Bencardino JT, Arnold E, Baccei SJ, Cassidy RC, et al. ACR appropriateness criteria osteoporosis and bone mineral density. J Am Coll Radiol. 2017;14(5):189-202.
[2] Mistry KA, Bhoil R, Sood D, Suthar P. Calculation of the reference bone mineral density values in North Indian population using phantomless quantitative computed tomography. J Orthop Allied Sci. 2018;6:33-37.
[3] Kanis JA, Melton LJ, Christiansen C, Johnston CC, Khaltaev N. The diagnosis of osteoporosis. J Bone Miner Res. 1994;9(8):1137-41.
[4] Lewiecki EM, Baim S, Langman CB, Bilezikian JP. The official positions of the international society for clinical densitometry: Perceptions and commentary. J Clin Densitom. 2009;12(3):267-71.
[5] Committee CS. Acr Practice guideline for the performance of Quantitative Computed Tomography (QCT) bone densitometry. Am Coll Radiol. 2008;1-10.
[6] Engelke K, Adams JE, Armbrecht G, Augat P, Bogado CE, Bouxsein ML. Clinical use of quantitative computed tomography and peripheral quantitative computed tomography in the management of osteoporosis in adults: the 2007 ISCD Official Positions. J Clin Densitom. 2008;11(1):123-62.
[7] Xu XM, Li N, Li K. Discordance in diagnosis of osteoporosis by quantitative computed tomography and dual-energy X-ray absorptiometry in Chinese elderly men. J Orthop Translat. 2018;18:59-64.
[8] Kong X, Tang L, Ma X, Liu W, Wang Z, Cui M, et al. Relationship between mild-to-moderate chronic kidney disease and decreased bone mineral density in Chinese adult population. Int Urol Nephrol. 2015;47(9):1547-53.
[9] Oei L, Koromani F, Rivadeneira F, Zillikens MC, Oei EH. Quantitative imaging methods in osteoporosis. Quant Imag Med Surg. 2016;6(6):680-98.
[10] Bauer JS, Virmani S, Mueller DK. Quantitative CT to assess bone mineral density as a diagnostic tool for osteoporosis and related fractures. Medicamundi. 2010;54:31-37.
[11] Summers RM, Baecher N, Yao J, Liu J, Pickhardt PJ, Choi JR, et al. Feasibility of simultaneous computed tomographic colonography and fully automated bone mineral densitometry in a single examination. J Comput Assist Tomogr. 2011;35:212-16.
[12] Pickhardt PJ, Lee LJ, del Rio AM, Lauder T, Bruce RJ, Summers RM. Simultaneous screening for osteoporosis at CT colonography: Bone mineral density assessment using MDCT attenuation techniques compared with the DXA reference standard. J Bone Miner Res. 2011;26:2194-203.
[13] Lenchik L, Weaver AA, Ward RJ, Boone JM, Boutin RD. Opportunistic screening for osteoporosis using computed tomography: State of the art and argument for paradigm shift. Curr Rheumatol Rep. 2018;20(12):74.
[14] Brett AD, Brown JK. Quantitative computed tomography and opportunistic bone density screening by dual use of computed tomography scans. J Orthop Translat. 2015;3(4):178-84.
[15] Adams JE. Quantitative computed tomography. Eur J Radiol. 2009;71:415-24.
[16] Li N, Li XM, XU L, Sun WJ, Cheng XG, Tian W. Comaprison of OCT and DXA: Osteoporosis detection rates in postmenopausal women. Int J Endocrinol. 2013;2013:895474.

PARTICULARS OF CONTRIBUTORS:
1. Assistant Professor, Department of Radiology, Hassan Institute of Medical Sciences, Hassan, Karnataka, India.
2. Senior Resident, Department of Radiology, Hassan Institute of Medical Sciences, Hassan, Karnataka, India.
3. Consultant Orthopaedic Surgeon, Department of Orthopaedics, Hassan Institute of Medical Sciences, Hassan, Karnataka, India.
4. Senior Resident, Department of Radiology, Hassan Institute of Medical Sciences, Hassan, Karnataka, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. SR Raghu,
No. 135, Lakshmiranga Nilaya, Hunsinkere Extension,
Hassan-573201, Karnataka, India.
E-mail: drraaghassan@gmail.com

PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Sep 19, 2020
- Manual Googling: Oct 13, 2020
- iThenticate Software: Nov 02, 2020 (23%)

ETYMOLOGY: Author Origin

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. Yes

Date of Submission: **Sep 18, 2020**
Date of Peer Review: **Oct 07, 2020**
Date of Acceptance: **Oct 13, 2020**
Date of Publishing: **Jan 01, 2021**