DOI: https://doi.org/10.54393/pjhs.v5i12.1811

PAKISTAN JOURNAL OF HEALTH SCIENCES
(LAHORE)
https://thejas.com.pk/index.php/pjhs
ISSN (P): 2790-9352, (E): 2790-9344
Volume 5, Issue 12 (Deccember 2024)

Original Article

OPEN ACCESS

Correlation of Dual-Energy X-Ray Absorptiometry and Quantitative Computerized Tomography in Detection of Osteoporosis among Postmenopausal Women

Shazia Yusuf[1], Saba Binte Kashmir[1*], Muhammad Afzal Abbasi[2], Humaira Riaz[3], Rana Muhammad Haseeb Kamran[4] and Romasa Zeb[5]

[1]Department of Radiology, Capital Hospital, Islamabad, Pakistan
[2]Department of Cardiology, Farooq Hospital, Islamabad, Pakistan
[3]Department of Radiology, International University, Rawalpindi, Pakistan
[4]Department of Cardiology, Amna Hayat Hospital, Lahore, Pakistan
[5]Army Medical College, Pakistan

ARTICLE INFO

Keywords:
Osteoporosis, Quantitative Computerized Tomography, Dual-Energy X-Ray Absorptiometry, Postmenopausal

How to Cite:
Yusuf, S., Kashmir, S. B., Abbasi, M. A., Riaz, H., Kamran, R. M. H., & Zeb, R. (2024). Correlation of Dual-Energy X-Ray Absorptiometry and Quantitative Computerized Tomography in Detection of Osteoporosis among Postmenopausal Women: Dual-Energy X-Ray Absorptiometry and Quantitative Computerized Tomography for Osteoporosis. Pakistan Journal of Health Sciences, 5(12), 260-264. https://doi.org/10.54393/pjhs.v5i12.1811

***Corresponding Author:**
Saba Binte Kashmir
Department of Radiology, Capital Hospital, Islamabad, Pakistan
sababintekashmir@yahoo.co.uk

Received date: 21st August, 2024
Accepted date: 13th December, 2024
Published date: 31st December, 2024

ABSTRACT

Osteoporosis is a serious health responsibility for clinicians, especially in postmenopausal patients. Dual-energy x-ray absorptiometry is currently the gold standard for the detection of osteoporosis, though its accuracy may be compromised due to concomitant degenerative changes. **Objectives:** To find out the detection rate of osteoporosis in women who have gone through menopause using both dual-energy X-ray absorptiometry and quantitative computerized tomography and to identify correlations between the two. To evaluate quantitative computerized tomography as a possible future imaging modality that can address the constraints of dual-energy x-ray absorptiometry. **Methods:** From June 2016 to July 2017, this cross-sectional study was carried out in the radiology Departments of Capital Hospital and Nuclear Medicine, Oncology and Radiotherapy Institute Hospital, Islamabad. With informed consent, seventy postmenopausal women participated. T-scores were calculated for quantitative computerized tomography and dual-energy x-ray absorptiometry, and data analysis, including the Pearson correlation coefficient, was conducted using SPSS-17. **Results:** The study included postmenopausal women aged 45–70, with menopause lasting over two years. The mean T-scores for quantitative computerized tomography and dual-energy x-ray absorptiometry were -2.4 ± 1.4 SD and -2.1 ± 1.3 SD, respectively. A strong positive correlation was established between quantitative computerized tomography and dual-energy x-ray absorptiometry T-scores ($r=0.808$; $p<0.05$). **Conclusions:** It was concluded that the study showed a constructive association between the T-scores obtained using quantitative computerized tomography and dual-energy x-ray absorptiometry, thus suggesting that quantitative computerized tomography can be used as an alternative to dual-energy x-ray absorptiometry in the detection of osteoporosis.

INTRODUCTION

Osteoporosis is a prevailing affliction condition mostly affecting older adults and women who have gone through menopause. It causes the strength of the bones to diminish, raising the risk of fracture. Reduced bone density and the bony microarchitecture breakdown, which leaves the bones porous or fragile, are the two main characteristics of osteoporosis [1]. The usual initial clinical presentation of osteoporosis is a fracture. Diagnosis and early management of osteoporosis is important as it has diverse clinical presentation; most patients with no symptoms wrongly believe that they may not be at risk for osteoporosis. Conversely, a lot of people who have widespread body pain mistakenly believe that osteoporosis is the cause of their symptoms. It is less likely to be true in the absence of fragility fracture. Without taking a bone mineral density (BMD) reading, one can make a clinical diagnosis of osteoporosis if a patient has a fragility fracture, especially in common places including the hip,

DOI: https://doi.org/10.54393/pjhs.v5i12.1811

wrist, humerus, ribs, and pelvis [2]. Future fractures of all kinds are strongly predicted by vertebral fractures [3]. Although fragility fractures (VFs) are the most prevalent form of fracture, only around two-thirds of vertebral fractures (VFs) are clinically recognized [4]. A method for looking at the spine to detect vertebral fractures (VFs) is called dual-energy x-ray absorptiometry (DXA) vertebral fracture assessment (VFA) [5]. Compared to traditional spine radiography, this may be completed during BMD testing, which offers more patient convenience, cheaper costs, and less radiation exposure [6]. The diagnosis of osteoporosis may only be considered final, by the classification by the World Health Organization (WHO), if the fragility fracture is missing and BMD can be determined by utilizing dual-energy x-ray absorptiometry (DEXA). The T-score of young people serves as a reference for the BMD threshold values that the WHO has supplied for osteoporosis and low bone mass. The difference in BMD between a patient and a young adult reference group, expressed as standard deviation (SD), is defined as T-score [7]. A T-score of 2.5 SD or below the mean BMD of the adult reference group specifies osteoporosis after controlling for other possible causes of reduced bone density and osteoporosis, such as osteomalacia [8]. The International Clinical Densitometry Society (ICDS) has created guidelines for applying WHO classification in clinical practice. The ICDS advises using the WHO recommendations for postmenopausal women and men over 50, but not for women before menopause and men under 50, due to variations in the relationship between BMD and fracture risk for younger women and men [9]. These days, there are several approaches available for determining bone mineral density. However, since DEXA provides the most exact and reliable estimation of BMD, it is the preferred approach for diagnostic categorization in clinical practice. However, some evidence suggests that there are still limitations to the clinical use of DXA. More than 80% of individuals with osteoporosis-related fragility fractures do not have comparable BMD levels, according to the research. Furthermore, DXA analysis relies on two-dimensional images and is unable to distinguish between cancellous and cortical bone. Furthermore, age-related degenerative changes such as the development of osteophytes, an increase in soft tissue density, and atherosclerosis can cause BMD measurements to be erroneously normal or high [10]. On the other hand, Quantitative Computerized Tomography (QCT) evaluates the hip and spine's volumetric bone density and separately examines cortical and trabecular bone. This method can be used to monitor therapy responses in people when notable progress might be observed [11]. As a result, noninvasive techniques to determine bone mineral density (BMD) are essential for monitoring the progression of osteoporosis and diagnosing it clinically. Dual X-ray absorptiometry (DEXA) and quantitative computed tomography (QCT) are frequently used techniques for calculating BMD. DEXA uses bi-dimensional analysis to evaluate bone mineral density (BMD), which includes both trabecular and cortical bone. In grams per square centimeter or areal density, the findings are shown. Without superimposing cortical bone and other tissues, volumetric trabecular bone density may be evaluated using QCT. In the 1970s, QCT was proposed as a method for assessing bone mineral density (BMD). However, CT technology was initially overlooked due to its limited development and the higher levels of radiation exposure. Recently, though, rapid advancements in CT technology have made it an effective tool for evaluating BMD [12]. DEXA is the primary method for diagnosing osteoporosis. However, its limitations—such as the inability to capture three-dimensional BMD measurements, inaccuracies from scanning artefacts, and BMD overestimation due to factors like aortic calcification, osteophytes, and other degenerative changes highlight the need for alternative imaging modalities that can address these issues. In our setting, we aim to compare QCT with the traditional DXA method for detecting osteoporosis in postmenopausal women. Since QCT is more accessible and less expensive than DEXA, it would be advantageous for patients if it could be demonstrated that its osteoporosis detection rate is equivalent to that of DEXA.

This study aims to find out the detection rates of osteoporosis in women who have gone through menopause using both DXA and QCT and to identify correlations between the two methods. The goal is to evaluate QCT as a possible future imaging modality that can address the limitations of dual-energy X-ray absorptiometry (DEXA).

METHODS

Imaging Radiology Departments of Capital and Nuclear Medicine, Oncology and Radiotherapy Institute (NORI) Hospital in Islamabad hosted this cross-sectional study from June 2016 to July 2017. Already diagnosed cases of multiple myeloma, rheumatoid arthritis, ankylosing spondylitis, connective tissue disease, metabolic or hormonal abnormalities, and primary or secondary skeletal cancers were excluded from the study. The sample size was determined using a sequential non-probability sampling approach, Level of significance=5%, using the WHO sample size calculator. After obtaining written informed consent on a structured form and ethical approval (IRB reference no. IRB-04-18-2-16), seventy postmenopausal women were included in the research following the exclusion of 40 patients. Patients meeting the criteria to be included in the study were selected from the outpatient Departments of Medicine, Gynaecology, and

DOI: https://doi.org/10.54393/pjhs.v5i12.1811

Radiology. Each participant received written information and was educated about the study's objectives and benefits before providing informed consent. Data pertinent to clinical presentation and demographic features of the selected patients was recorded. Both imaging procedures were performed by a skilled technician, under the supervision of the trainee researcher, with a one-month interval between them. Similar regions of interest (ROI) were drawn on the lumbar spine for both the techniques by trainee researcher. DXA T-scores were measured using the software, based on the Chinese reference database. Scans were performed on the left hip and supine vertebrae from L1 to L4 in post-anterior projections. QCT measurements were taken using a 64-slicer Toshiba-AQUILION multi-detector CT scan machine, incorporating the Mind-way QCT phantom. Scans of the L1 through L4 vertebrae were taken keeping the patient in the supine position. Mind-ways software analyzed the images by automatically placing elliptical regions of interest in the mid-plane of three vertebral bodies (L2–L4) in the region of trabecular bone, automatically avoiding cortical bone. Vertebrae with fractures were not included in the measurements. Both the International Society for Clinical Densitometry (2007) and the American College of Radiology (2008) thresholds were used for trabecular BMD for spine: 80 mg/cm^3 for osteoporosis (equal to a DXA T-score of -2.5 SD) and 120 mg/cm^3 for osteopenia (equal to a DXA T-score of -1.0 SD). A consultant radiologist verified the final reports, and T-scores were computed for both QCT and DXA. Data analysis was performed using SPSS-17. Continuous variables, including age, BMI, and BMD values from DXA and QCT, were reported as means and standard deviations. Pearson correlation coefficients were used to assess T-score correlations between QCT and DXA using a Bivariate correlation procedure. p-values were considered statistically significant if less than 0.05. Stratification by age, menopausal duration, and BMI were applied to control for confounding factors. Post-stratification analysis with Pearson correlation testing considered p-value=<0.05 as significant.

RESULTS

The mean value of T-scores obtained using QCT and DEXA methods was -2.4 ± 1.4 SD and -2.1 ± 1.3 SD, respectively. Assuming that both variables were approximately normally distributed, "The Bivariate Correlations procedure" in SPSS version 17 was used to correlate the two T-scores. The results of computing the pairwise associations for the set of both variables were shown in a matrix. T-scores determined by QCT and DEXA had a substantial and high positive connection (p<0.05), according to the computed correlation value of 0.808 (Table 1).

Table 1: Correlation Between the Whole Research Sample's Mean T-Scores as Determined by QCT and DEXA

Variables		T Score QCT	T Score DEXA
T-Score QCT	Pearson Correlation	1	0.808
	Sig. (2-Tailed)		0.0001
	n	70	70
T-Score DEXA	Pearson Correlation	0.808	1
	Sig. (2-Tailed)	0.0001	
	N	70	70

Age, BMI, T-scores and duration of menopause in the study population are tabulated (Table 2).

Table 2: Mean Age, BMI, T-Scores and Duration of Menopause in Study Sample

Variables	Mean + SD
Age (Years)	59.6 ± 6.9
BMI (Kg/M^2)	25.5 ± 8.7
T Score Qct	-2.4 ± 1.4
T Score Dexa	-2.1 ± 1.3
Duration of Menopause (Years)	14.9 ± 6.2

In the age group 45-55 years, the correlation coefficient calculated was 0.851, and in the age group 56-70 years, it was 0.751, suggesting that T-scores obtained by DEXA and QCT have a substantial and favourable connection (p<0.05) (Table 3).

Table 3: Correlation Between Mean T-Scores Measured Through QCT and DEXA in Age-Based Stratification

Age 45-55 Years		T Score QCT	T Score DEXA
T-Score QCT	Pearson Correlation	1	0.851
	Sig. (2-Tailed)	-	0.0001
	N	23	23
T-Score DEXA	Pearson Correlation	0.851	1
	Sig. (2-Tailed)	0.0001	-
	N	23	23
Age 55-70 Years			
T-Score QCT	Pearson Correlation	1	0.759
	Sig. (2-Tailed)	-	0.0001
	N	47	47
T-Score DEXA	Pearson Correlation	0.759	1
	Sig. (2-Tailed)	0.0001	-
	N	47	47

T-scores determined by QCT and DEXA show a high positive association (p<0.05) with a correlation coefficient of 0.866 in women who have gone through menopause for less than ten years and 0.760 in women who have gone through menopause for more than ten years (Table 4).

Table 4: Correlation Between Mean T-Scores Measured Through QCT and DEXA (Menopause)

Menopause of ≤10 Years		T Score QCT	T Score DEXA
T-Score QCT	Pearson Correlation	1	0.866
	Sig. (2-Tailed)	-	0.0001
	N	16	16

DOI: https://doi.org/10.54393/pjhs.v5i12.1811

T-Score DEXA	Pearson Correlation	0.866	1
	Sig. (2-Tailed)	0.0001	-
	N	16	16
Menopause Of >10 Years			
T-Score QCT	Pearson Correlation	1	0.760
	Sig. (2-Tailed)	-	-
	N	54	54
T-Score DEXA	Pearson Correlation	0.760	1
	Sig. (2-Tailed)	-	-
	N	54	54

DISCUSSION

An evaluation of bone mineral density can be used to speculate the likelihood of osteoporotic fractures. Dual-energy X-ray absorptiometry (DEXA) and quantitative computed tomography (QCT) are two extensively used techniques for diagnosing osteoporosis. In the mid-1970s, Quantitative Computed Tomography (QCT) saw the introduction of its initial iteration. This technique is usually used to measure the bone mineral density (BMD) in (mg/cm3) of the trabecular bone of the lumbar spine [13]. In contemporary diagnostic and therapeutic guidelines, DEXA is still assigned as the "gold standard" to identify osteoporosis and foresee fracture risk [14]. However, without using ionizing radiation, quantitative ultrasound (QUS) and quantitative magnetic resonance (QMR) offer novel methods to evaluate bone microarchitecture besides the density of bone minerals [15]. A special benefit of whole-body scanners for quantitative computed tomography (QCT) is the ability to pick the individual components of bone mineral density (BMD) including trabecular, cortical, and subcortical BMD most notably in the hip and spine, although the distal forearm may also be examined [16, 17]. Treatment effects have a greater impact on trabecular architectural parameters than BMD. It is appropriate for treated patients who follow their treatment plan to see stability or an increase in BMD. A study found that opportunistic QCT screening inhibited 2.6 further VFs for every 1,000 women and 2 extra VFs for every 1,000 males. The probabilistic sensitivity analysis showed that QCT screening remained economical in 90.0% of iterations for males and 88.3% for females [18]. Another study revealed that in individuals with fragility compression fractures of the vertebrae, DXA failed to detect osteoporosis [19]. A comparative study between DXA and QCT concluded that QCT is better in the evaluation of lumbar osteoporosis than DXA [20]. We conducted the current study because there is a dearth of evidence-based information about BMD assessment. In this work, we discovered a link between postmenopausal osteoporotic women's mean bone mineral density (BMD), as determined by dual-energy X-ray absorptiometry, and quantitative computed tomography. The T-scores acquired by QCT and DEXA demonstrated a mean value of -2.4 ± 1.4 SD and -2.1 ± 1.3 SD, respectively, based on our findings. A noteworthy and substantial positive correlation (r=0.808; p<0.05) was discovered between the T-scores derived by DEXA and QCT. A similar pattern was seen after stratification by age, BMI, and menopause duration.

CONCLUSIONS

It was concluded that QCT offers accurate osteoporosis detection comparable to DXA, showing a significant correlation between the two methods. Additionally, QCT can help prevent DXA from overestimating bone mineral density (BMD) when other sclerotic conditions are present, such as bone islands, spinal degeneration, and atherosclerosis. While QCT may be more sensitive in identifying osteoporosis, additional studies with high sample sizes are needed to confirm its effectiveness.

Authors Contribution

Conceptualization: SY
Methodology: SY, SBK, MAA, RMHK
Formal analysis: MAA, HR, RMHK
Writing review and editing: HR, RZ

All authors have read and agreed to the published version of the manuscript

Conflicts of Interest

All the authors declare no conflict of interest.

Source of Funding

The author received no financial support for the research, authorship and/or publication of this article.

REFERENCES

[1] Langdahl BL. Overview of Treatment Approaches to Osteoporosis. British Journal of Pharmacology.2021 May; 178(9): 1891-906. doi: 10.1111/bph.15024.

[2] Dimai HP and Fahrleitner-Pammer A. Osteoporosis and Fragility Fractures: Currently Available Pharmacological Options and Future Directions. Best Practice and Research Clinical Rheumatology.2022 Sep; 36(3): 101780. doi: 10.1016/j.berh.2022.101780.

[3] Lorentzon M, Johansson H, Harvey NC, Liu E, Vandenput L, McCloskey EV *et al*. Osteoporosis and Fractures in Women: The Burden of Disease. Climacteric.2022Jan;25(1):4-10.doi:10.1080/13697137 .2021.1951206.

[4] Himič V, Syrmos N, Ligarotti GK, Kato S, Fehlings MG, Ganau M. The Role of Genetic and Epigenetic Factors in Determining the Risk of Spinal Fragility Fractures: New Insights in the Management of Spinal Osteoporosis. Quantitative Imaging in Medicine and Surgery. 2023 Nov; 13(11): 7632. doi: 10.21037/qims-23-513.

DOI: https://doi.org/10.54393/pjhs.v5i12.1811

[5] Khan AA, Slart RH, Ali DS, Bock O, Carey JJ, Camacho P *et al*. Osteoporotic Fractures: Diagnosis, Evaluation, and Significance from the International Working Group on DXA Best Practices. In Mayo Clinic Proceedings.2024Jul:99(7):1127-1141.doi:10.1016/j.mayocp.2024.01.011.

[6] Kennel KA and Drake MT. The Long and Winding Road to Improving Bone Mineral Density Testing and Reporting. In Mayo Clinic Proceedings. 2024 Jul; 99(7): 1027-1029. doi: 10.1016/j.mayocp.2024.05.008.

[7] Camacho PM, Petak SM, Binkley N, Diab DL, Eldeiry LS, Farooki A *et al*. American Association of Clinical Endocrinologists/American College of Endocrinology Clinical Practice Guidelines for the Diagnosis and Treatment of Postmenopausal Osteoporosis 2020 Update. Endocrine Practice.2020 May; 26: 1-46.doi:10.4158/GL-2020-0524SUPPL.

[8] LeBoff MS, Greenspan SL, Insogna KL, Lewiecki EM, Saag KG, Singer AJ *et al*. The Clinician's Guide to Prevention and Treatment of Osteoporosis. Osteoporosis International.2022Oct;33(10):2049-102. doi: 10.1007/s00198-021-05900-y.

[9] Amarnath SS, Kumar V, Das SL. Classification of Osteoporosis. Indian Journal of Orthopedics.2023 Dec; 57(Suppl 1): 49-54. doi: 10.1007/s43465-023-01058-3.

[10] Pu M, Zhang B, Zhu Y, Zhong W, Shen Y, Zhang P. Hounsfield Unit for Evaluating Bone Mineral Density and Strength: Variations in Measurement Methods. World Neurosurgery.2023Dec;180:e56-68.doi:10.1016/j.wneu.2023.07.146.

[11] Gruenewald LD, Koch V, Martin SS, Yel I, Eichler K, Gruber-Rouh T *et al*. Diagnostic Accuracy of Quantitative Dual-Energy CT-Based Volumetric Bone Mineral Density Assessment for the Prediction of Osteoporosis-Associated Fractures. European radiology. 2022 May; 32: 1-9. doi: 10.1007/s00330-021-08323-9.

[12] Alawi M, Begum A, Harraz M, Alawi H, Bamagos S, Yaghmour A *et al*. Dual-Energy X-Ray Absorptiometry (DEXA) Scan Versus Computed Tomography for Bone Density Assessment. Cureus.2021 Feb; 13(2). doi: 10.7759/cureus.13261.

[13] Fang Y, Li W, Chen X, Chen K, Kang H, Yu P *et al*. Opportunistic Osteoporosis Screening in Multi-Detector CT Images Using Deep Convolutional Neural Networks. European Radiology. 2021 Apr; 31: 1831-42. doi: 10.1007/s00330-020-07312-8.

[14] Do TD, Rahn S, Melzig C, Heußel CP, Stiller W, Kauczor HU *et al*. Quantitative Calcium-Based Assessment of Osteoporosis in Dual-Layer Spectral CT. European Journal of Radiology.2024 Sep; 178: 111606. doi: 10.1016/j.ejrad.2024.111606.

[15] Chen M, Gerges M, Raynor WY, Park PS, Nguyen E, Chan DH *et al*. State of the Art Imaging of Osteoporosis. In Seminars in Nuclear Medicine.2024 May;54(3):415-426. doi: 10.1053/j.semnuclmed.2023.10.008.

[16] Dheeraj D, Chauhan U, Khapre M, Kant R. Comparison of Quantitative Computed Tomography and Dual X-Ray Absorptiometry: Osteoporosis Detection Rates in Diabetic Patients.Cureus.2022Mar;14(3).doi:10.7759/cureus.23131.

[17] Cheng X, Zhao K, Zha X, Du X, Li Y, Chen S *et al*. Opportunistic Screening Using Low-Dose CT and the Prevalence of Osteoporosis in China: A Nationwide, Multicenter Study. Journal of Bone and Mineral Research.2020 Dec; 36(3): 427-35. doi:10.1002/jbmr.4187.

[18] Rühling S, Schwarting J, Froelich MF, Löffler MT, Bodden J, Hernandez Petzsche MR *et al*. Cost-Effectiveness of Opportunistic QCT-Based Osteoporosis Screening for the Prediction of Incident Vertebral Fractures. Frontiers in Endocrinology.2023 Jul; 14: 1222041. doi: 10.3389/fendo.2023.1222041.

[19] Paggiosi MA, Debono M, Walsh JS, Peel NF, Eastell R. Quantitative Computed Tomography Discriminates Between Postmenopausal Women with Low Spine Bone Mineral Density with Vertebral Fractures and Those with Low Spine Bone Mineral Density Only: The SHATTER Study. Osteoporosis International.2020 Apr; 31: 667-75. doi: 10.1007/s00198-020-05317-z.

[20] Lin W, He C, Xie F, Chen T, Zheng G, Yin H *et al*. Discordance in Lumbar Bone Mineral Density Measurements by Quantitative Computed Tomography and Dual-Energy X-Ray Absorptiometry in Postmenopausal Women: A Prospective Comparative Study. The Spine Journal.2023 Feb; 23(2): 295-304. doi: 10.1016/j.spinee.2022.10.014.