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Quantitative computed tomography is a novel diagnostic tool for early scrutiny of osteopenia and/or osteoporosis

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ABSTRACT

Background: Osteoporosis is a significant public health concern, particularly affecting women. Accurate diagnosis of osteoporosis is crucial for early intervention. This study aimed to evaluate the effectiveness of Quantitative Computed Tomography (QCT) and Dual-Energy X-ray Absorptiometry (DXA) scans in individuals suspected of having osteoporosis.

Methods: A cross-sectional study was conducted at the Islamabad Diagnostic Centre from June 2022 to June 2023. Participants suspected of having osteoporosis were recruited and underwent QCT and DXA scans. QCT evaluated inner trabecular bone, while DXA assessed bone mineral density (BMD). Diagnostic findings were compared.

Results: Of the participants, 89.3% had lower average QCT-T scores than DXA-T scores. QCT detected osteopenia in 96.6% and osteoporosis in 57.1% of subjects, while DXA identified osteopenia in 65% and osteoporosis in 10.7%. QCT demonstrated early detection potential, particularly for osteoporosis.

Conclusion: QCT is a reliable tool for early diagnosis of osteopenia and osteoporosis, as it accurately assesses inner spongy trabecular bone. It offers advantages over DXA, including cost-effectiveness in low- and middle-income countries. Global health strategies should prioritize osteoporosis assessment, considering the findings of this study.

Keywords: Quantitative Computed Tomography, Dual-Energy X-ray Absorptiometry, Osteoporosis.

Introduction

Osteoporosis is distinguished by a weakening of the bones that makes them more likely to fracture.[1] Bones become brittle and porous, like a frail sponge. Depending on their diet, way of life, and heredity, anyone can get osteoporosis. The Centers for Disease Control and Prevention (CDC) in the USA found that if untreated 43% of adults over 50 having low bone mass can develop osteoporosis, 12.6% of those over 50 had osteoporosis.[2] Osteoporotic fractures are mild trauma fractures because they frequently happen with forces comparable to or even lower than falling from as low as standing height. Dependence on others and osteoporosis can both significantly reduce a person's quality of life.[3]

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Osteoporosis is a worldwide public health issue that affects people in high-, middle-, and low-income nations. However, there are noticeable variations between these nations in terms of prevalence, risk factors, access to treatment, and management techniques. Because of other urgent medical issues, osteoporosis may not receive appropriate treatment in low-income nations. High prevalence of infectious diseases, poor access to healthcare, and malnutrition frequently take precedence.[4] Compared to high-income nations, the prevalence of osteoporosis tends to be lower, primarily because the population is often younger and has a shorter life expectancy. However, osteoporosis is projected to become a bigger problem in the future as life expectancies rise and lifestyles change. Osteoporosis is becoming more common in middle-income nations as a result of urbanization, sedentary lifestyles, and dietary changes. These nations frequently go through a "nutrition transition" with rising processed food intake and declining levels of physical exercise. In addition, some cultural

practices, such as limiting sun exposure and consuming little calcium, can hasten the onset of osteoporosis. In some middle-income nations, inadequate access to healthcare, to medications and diagnostic equipment, can be problematic. Numerous factors contribute to the higher frequency of osteoporosis in high-income countries. Longer life expectancies, an ageing population, and a rise in the incidence of risk factors like smoking, binge drinking, and a sedentary lifestyle are a few of these. These nations often have easier access to medical services, prescribed drugs and diagnostic testing, allowing for early diagnosis and management of osteoporosis.[4]

High-income nations frequently have more widespread health education and public awareness programs that emphasize the significance of lifestyle changes, such as consistent exercise and a diet high in calcium. It is crucial to remember that, despite possible differences in the frequency and treatment of osteoporosis within socioeconomic categories, the disease nonetheless poses a serious threat to global public health. In order to lessen the impact of osteoporosis and the fractures it causes, efforts must be made to increase awareness, access to healthcare, and preventive measures.[5]

Years of healthy life lost as a result of impairment and early death are referred to as impairment-Adjusted Life Years (DAL). It is crucial to address misdiagnosis and its possible consequences in terms of the overall burden of disease, even though osteopenia is not often linked with considerable impairment or mortality on its own. Osteopenia misdiagnosis can result in a number of different results. A false diagnosis could result in needless therapy with drugs like bisphosphonates or other measures. The patient could not get the right care for their actual ailment, and these treatments could have dangers and adverse effects.[6]

Since Osteopenia is thought to be a precursor to osteoporosis, misdiagnosis of Osteopenia may prevent the identification of those who have advanced to osteoporosis. These people may have a higher risk of fractures without the proper diagnosis and treatment. The incorrect diagnosis of Osteopenia may draw attention away from other underlying issues that may be causing low bone density. For instance, certain illnesses (such as hormonal imbalances or gastrointestinal diseases) or drugs (such as corticosteroids) can result in secondary osteoporosis.

If these underlying causes are not identified, diagnosis and therapy may be delayed. Since DALYs are typically a measure used for more serious medical disorders that result in significant disability and mortality, it is difficult to precisely evaluate the effect of Osteopenia misdiagnosis on DALYs. Misdiagnosis, however, may indirectly add to the overall burden of disease by raising healthcare expenditures, prompting pointless procedures, and delaying proper management.[6]

Healthcare professionals should adhere to established protocols and use precise diagnostic methods, such as dual-energy X-ray absorptiometry (DXA) scans to measure bone density, to reduce the chance of misdiagnosis. In addition, accurate medical history-taking and assessment of individual risk factors can aid in locating the root causes of low bone density and assist avoid misdiagnosis. The potential negative effects of a misdiagnosis can be minimised, and the burden of issues related to osteoporosis can be lessened, with prompt and correct diagnosis and the right management.

Women's post-menopausal estrogen levels cause their bone mineral density to fall after the age of 40, which can lead to bone illnesses such osteomalacia, osteopenia, osteoarthritis, and others. In Pakistani women, osteoporosis is a frequent problem.[7] One of the most prevalent health problems is calcium deficiency, and there are numerous programs to increase public awareness of it through television advertising and other social media networking. 97% of Pakistani women between the ages of 75 and 84 and 55% of those between the ages of 40 and 54 had osteoporosis risk.[7] Even in industrialized countries where the disease is well-known, there is still need for improvement in how clinicians screen for, diagnose, and treat fragility fractures with a focus on osteoporosis. Despite major breakthroughs in diagnostic technology and limited public awareness, few people were diagnosed before the disease took hold of them.[8]

Methods

A cross-sectional study was conducted during the months of june 2022 to june 2023 at the Islamabad Diagnostic Centre, located in Islamabad, Pakistan. The study aimed to evaluate the efficacy of diagnostic tools for osteoporosis among individuals who were suspected of having the condition. Participants in this study were individuals who were suspected of having osteoporosis. Recruitment of participants was carried out through various means, and individuals who met the inclusion criteria were invited to participate. Prior to the assessment, all recruited participants underwent a comprehensive informed consent process. Ethical

guidelines and principles were strictly adhered to during this process. The ethical review board of Islamabad diagnostic center approved the study (Re:IDCERBO9202304 dated 02.02.2022).

The study utilized a combination of advanced diagnostic tools to assess bone health and detect osteoporosis. These tools included: QCT scans were performed using a CT scanner, specifically the GE Optima MR 360 USA. QCT is a highly sensitive method for evaluating bone density and structure, particularly the inner trabecular bone. DXA scans were conducted using the Fan Beam DXA technology, provided by Hologic. DXA is a standard method for assessing bone mineral density (BMD) and is commonly used in diagnosing osteoporosis. BMD testing, which is integral to osteoporosis diagnosis, was included as part of the assessment process. Radiological findings obtained from the QCT and DXA scans, as well as BMD testing, were meticulously evaluated. The evaluation was conducted following internationally recognized standardized operating procedures. These procedures were in line with recommendations provided by the World Health Organization (WHO) and the United States Food and Drug Administration (USFDA). The required sample size for this study was determined using a standardized formula, $n = (z\ \alpha\ /\ 2\ \sigma\ E)\ 2$. The study employed a rigorous and well-planned approach to assess osteoporosis among individuals suspected of having the condition.

Results

The enrolled participants were independently diagnosed for quantitative computed tomography (QCT) and dual-energy X-ray absorptiometry (DXA scan), also known as bone mineral density (BMD) or bone density test, in order to investigate the osteoporosis among probable patients. 100 individuals were enlisted, and 69.3% of them were female and 30.7% were male. Males and females had average BMIs of 31.02 and 27.23 respectively. 89.3% of the participants had an average QCT-T score that was considerably lower than the average DXA-T score of the patients who were being observed. One noteworthy finding was that the QCT analysis verified the start of osteoporosis/Osteopenia in a small number of symptomatic probable osteoporotic individuals whose DXA scans were normal.

According to this, QCT may be more sensitive than previously believed to the early detection of patients who are suspected of having osteoporosis, which is advantageous for rapid treatment. According to the study, 10.7% of individuals had comparable QCT-T and DXA-T values. DXA-T values that were higher than QCT-T scores were only present in 5.56% of the patients. People with osteoporosis or osteopenia benefit significantly from early therapy initiation in terms of their outcomes.

After the QCT-T score data from recruited participants were analyzed, osteopenia was discovered in 96.6% of subjects and osteoporosis in 57.1% of respondents. According to table 1, osteopenia was found in 65% of individuals and osteoporosis in 10.7% of subjects after DXA T score investigation on the same patients in the same positions. The DXA T score, which examines the bone mineral density of the cortical shell and trabecular bone structure, has a higher T score than the QCT, which only evaluates the inner portion of the trabecular bone structure.

Because the partial deposition of additional layers of mineral to the outside of the cortical layer, which affects DXA reading, can mask the loss of the inner bone among patients (like the termite eating the stem), relying solely on DXA T scores rather than QCT may not be the best option for some doctors.

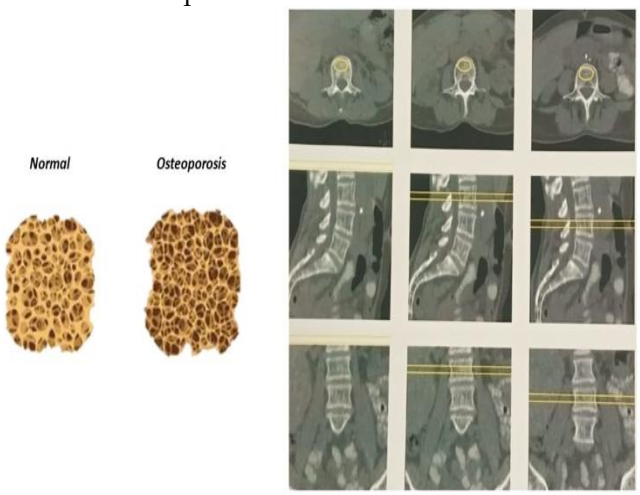

Fig 1. Examination of osteoporotic versus normal bone in comparison

As seen in Figure 1, the QCT accurately identifies the important inner spongy trabecular area. Therefore, early identification by QCT can stop suspected osteoporosis patients' vertebrae from suddenly collapsing. The lower T-score of QCT scans may help osteoporotic patients receive an early diagnosis.

Table.1: Diagnostic evaluation of QCT and DXA performed on suspected patients of osteoporosis.

Disease	Diagnostic Tools	
	QCT	DXA
Osteoporosis	57.1%	10.7%
Osteopenia	96.6%	65%

Discussion

The Sustainable Development Goals (SDGs) context frequently overlooks osteoporosis. The SDGs are a series of international objectives designed to solve numerous social, economic, and environmental concerns in order to achieve sustainable development by 2030. They were endorsed by the United Nations in 2015. The SDGs do not expressly list osteoporosis as a target, however it is linked to a number of other goals and objectives.[9] The following are a few ways that osteoporosis is associated with the SDGs. Osteoporosis is a substantial contributor to morbidity and death, particularly in older persons, according to SDG 3: Good Health and Well-Being. Fractures, loss of mobility, persistent pain, and a lower quality of life can result from it. Goal 3 can be advanced through encouraging early detection, prevention, and effective management of osteoporosis, especially Target 3.4, which aims to decrease premature mortality from non-communicable diseases. Goal 5 on gender equality states that osteoporosis disproportionately affects women, especially after menopause because of hormonal changes that quicken bone loss. By addressing osteoporosis, efforts can be made to lessen health disparities between men and women and to ensure that female patients have access to accurate diagnosis, effective treatments, and management assistance.[9] Similarly, as per reduced inequalities Goal 10 of SDGs, among diverse population groups, notably those in low-income and marginalized communities, osteoporosis prevalence and management can vary. By treating osteoporosis, efforts can be made to lessen health disparities and guarantee that people from all socioeconomic backgrounds have equal access to prevention, diagnosis, and treatment. Also, as per Sustainable Cities and Communities goal 11 of SDGs, the older individuals' independence and well-being can be greatly impacted by osteoporosis and accompanying fractures, which can limit their capacity to fully engage in society. The entire quality of life for people with osteoporosis can be improved by fostering policies that support active ageing and age-friendly surroundings, which can help avoid falls and fractures. Although osteoporosis may not have been specifically addressed in the SDGs, initiatives to support healthy ageing, avoid non-communicable diseases, and lessen healthcare disparities can indirectly help with osteoporosis management. In the context of the SDGs, it is critical to promote increased understanding of osteoporosis and emphasise the significance of bone health as a component of overall wellbeing and sustainable development.[9] For patients undergoing primary CT studies of the abdominal pelvis, there is an opportunity for concurrent BMD screening, providing an added diagnostic value without requiring additional radiation exposure or extending the patient's examination time

Although Fan Beam DXA, which uses low-dose X-rays rather than QCT to scan the bones (i.e., about 1/10th of the radiations of standard Chest X-ray), has remained the gold standard for osteoporosis (recommended for patients over 65, typically in those with diabetes, taking corticosteroids, or who have a history of broken bones because of lower impact). Because it carefully evaluates the condition of the interior spongy bone of the spine, the QCT-based detection is more significant for determining the severity of the disease in the real world.[10] DXA evaluates the quality of bone in at least two different parts of the body, typically the hips and lower spine. The standard T score, which compares the bone density to that of people whose ages are matched, is used to interpret the DXA scan results.[11] DXA is a cheap method of analysis, and only very little radiation is needed. While the QCT typically only assesses the interior portion of the bone, bone mineral density of both the outer shell and the inside structure of the bone are evaluated by DXA. With DXA alone, the majority of persons with osteopenia or osteoporosis can be missed.[12] The average QCT-T score in this study was shown to be lower than the DEXA-T scores acquired from patients in comparable regions based on the research analysis of enrolled individuals. [13]According to the results of the QCT-T score, our data revealed that 89.3% of the participants were more likely to develop osteopenia or osteoporosis. The American Bone Health Fracture Risk Calculator was created to give users over the age of 45 a way to estimate their risk of breaking a bone during the next ten years .[10] According to a recent study, QCT scans may be more appropriate for early diagnosis, accurately identify the inner spongy bone, and convenience than DXA scans for the analysis of osteopenia and osteoporosis among suspected patients because QCT can be used in already existing common CT/CAT scan setups, whereas DXA scans require more money for installation and management.[11-14]

Conclusion

It can be concluded that DXA can be used for general illness screening, but that QCT-based analysis is preferred for correct identification of clinically suspected patients when DXA does not correspond.

Additionally, this research would pave the way for future clinical studies involving individuals with co morbid conditions like diabetes and vitamin deficiencies.

Conflicts of Interest: None declared.
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