International Journal of Radiography Imaging & Radiation Therapy
IJRIRT, 1(2): 36-37
www.scitcentral.com
ISSN: 2642-0392
Editorial: Open Access

Computed Tomography for Opportunistic Screening of Osteoporosis

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Received May 28, 2019; Accepted May 31, 2019; Published July 21, 2019

INTRODUCTION

Osteoporosis is a globally prevalent disorder that results from deterioration of bone mineral density (BMD) and microarchitecture leading to diminished bone strength and increased risk of fracture due to skeletal fragility. Osteoporosis can be defined by either a low BMD (T-score <2.5) or evidence of a fragility fracture, particularly of the hip and spine [1]. Estimates predict that prevalence and costs related to osteoporosis may increase by 50% within the next few years due to the aging population. Currently, more than 10 million Americans are affected by osteoporosis, more than 40 million have low BMD, and more than 1.5 million osteoporosis-related fractures occur annually. Women have a lifetime risk for any osteoporosis-related fracture of approximately 50%. Osteoporosis and related morbidities are responsible for as many as 2.5 million office visits, over 400,000 hospital admissions, and greater than $15 billion annually in direct costs [2]. The effects of osteoporosis-related fractures on quality of life include impairment of activities of daily life (ADL), chronic pain, increased risk of death, loss of enjoyment of activities, depression, and dependence often requiring assistance such as in a nursing home. The effect on quality of life is so severe that 80% of women older than 75 years stated they would prefer death over placement in a nursing home following hip fracture [3]. Therefore, the actual cost of osteoporosis is grossly underestimated when considering indirect financial costs and impact on quality of life, including physical, mental and financial well-being.

Current screening recommendations for osteoporosis from the United States Preventive Task Force (USPTF) Services state that post-menopausal women older than 65 years and younger than 65 years with higher risk should be screened with BMD scans every 2 years to prevent osteoporotic fractures (grade B recommendation) [4]. However, successful screening rates for osteoporosis remain concerningly low. After Medicare instituted reimbursement for osteoporosis screening in the early 2000's, one study reported that less than 21% of female's ages 65-89 year completed the screening. A follow up national study of Medicare recipients aged 65 year+ reported less than 10% women completed screening from 2002-2009. Gillespie and Morin reported that screening rates from 2008-2014 show little to no improvement, with 26% completion in ages 65-79 year, but only 12% completion for 80+ years [5]. Poor screening has contributed to under diagnosing and undertreating osteoporosis, often leading to the development of subsequent fragility fractures. Barton et al. found that 94% of patients presenting for a vertebral compression fracture had not received a bone scan in the previous 2 years, only 7% initiated an anti-resorptive medication after the fracture and 38% developed an additional fragility fracture within 2 years [6]. There is also inadequate treatment of osteoporosis globally. Data from 6 European countries indicate that 60-85% of women did not receive appropriate treatment following a fracture. The estimated economic and social cost of osteoporosis-related fractures in these countries shows comparable trends to those in the United States [7].

Dual-energy x-ray absorptiometry (DXA) is considered the reference standard for evaluation of BMD and diagnosis of osteoporosis given its relatively low cost and radiation exposure. In light of the severe underutilization of screening, recent studies have evaluated whether computed tomography (CT) should be used as an opportunistic screening tool in patients who have already undergone a CT for another indication. With more than 80 million CT scans performed

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Citation: Cromer M, Verma V & Kant R. (2019) Computed Tomography for Opportunistic Screening of Osteoporosis. Int J Radiography Imaging Radiat Ther, 1(2): 36-37.

in the US in a single year, there is a wealth of opportunity for improving osteoporosis screening efforts by opportunistically assessing bone quality from these scans. This analysis could be easily completed and would require minimal training and time, no additional equipment and no additional cost, radiation exposure or time from the patient.

Pickhardt et al. [8] compared CT-attenuation values of trabecular bone (between the T12 and L5 vertebral levels) with DXA derived BMD in 1867 adults undergoing CT and DXA within a 6 month period over 10 years. CT-attenuation threshold of 160 Hounsfield Units (HU) was found to be 90% sensitive in detecting osteoporosis BMD and a threshold of 110 HU was 91% specific. It's important to note that DXA scan demonstrated non-osteoporotic T-scores in 52.1% of patients with at least 1 moderate to severe vertebral fracture. However, almost all of the patients with vertebral fracture (97%) had CT-attenuation of 145 HU or less suggesting that CT-derived BMD assessment may be a better measure of bone quality. Similar findings were reported by Alacreu et al. [9] with greater than 90% sensitivity for detecting osteoporosis BMD at 160 HU, but greater than 90% specificity was achieved at a threshold of 73 HU. More than half of the patients with vertebral compression fracture had DXA scan T-scores in osteopenic or normal range.

Gausden et al. [10] systemically reviewed 10 studies analyzing correlation between DXA and CT-derived BMD measures. Only 5 of these studies reported threshold HU to diagnose osteoporosis, which varied widely among studies. The mean HU value ranged 54.7 to 130 in lumbar spine that were osteoporotic based on DXA scan. Differences in these results could be partly explained by CT scanner-to-scanner variability in measuring HU. Furthermore, there are concerns over the quality, institutional variability, and dependability of DXA scans along with their ability to accurately detect osteoporosis BMD [11]. Several studies have reported that patients with known vertebral compression fractures had received osteopenic and even normal DXA T-scores, yet CT imaging was capable of diagnosing the osteoporotic BMD independent of the DXA T-score [8,9].

Osteoporosis is an insidious chronic disease with significant global impact that needs higher quantity as well as quality screening opportunities to promote beginning appropriate therapy for adequate primary and secondary prevention. Initiating treatment before a primary fragility fracture occurs can reduce the risk of incidental fracture by 75% and subsequently reduces the 5 year fracture incidence risk from 34% to 10% [12]. Opportunistic screening with CT analysis could provide an additional barrier in the development of osteoporosis and fragility fractures, allowing for greater opportunities in diagnosis and treatment which will reduce long-term risks of fracture-related morbidity and mortality. Even though the data on opportunistic use of CT-attenuated HU values to diagnose osteoporosis is very exciting, further research is needed before it can be clinically implemented. The lack of exchangeability among CT machines poses a limitation to its wide-spread applicability. Future direction for research should be to establish recognized HU thresholds for anatomic sites for valid CT diagnosis of osteoporosis [10].

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