Evaluation of the tibial cortical thickness accuracy in osteoporosis diagnosis in comparison with dual energy X-ray absorptiometry

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ABSTRACT

Background: Unlike public awareness around the world, osteoporosis is still underdiagnosed in most cases till bone fractures. Currently, the dual-energy X-ray absorptiometry (DEXA) is the gold standard diagnostic method of osteoporosis, but unfortunately this method is not available in all diagnostic centers, especially in developing countries. Aims: To evaluate the accuracy of tibial cortical thickness in the diagnosis of osteoporosis compared with DEXA. Materials and Methods: In this descriptive–analytic study, patients suspicious of osteoporosis who referred to Imam Khomeini Hospital, Ahvaz from 2016–2017 were recruited. Data was collected for each patient including age, sex, radiography, and DEXA. The total thickness of the tibia cortex (sum of the two sides) was measured using knee anteroposterior radiography at 10 cm from the proximal tibial joint. The bone mineral density (BMD) was measured by DEXA method and reported as T-score. Results: In this study, 62 patients (90% female) were evaluated. The mean age of the patients was 57 years (range 45–80 years). T-score had a direct significant correlation with TCT level ($r = 0.51, P < 0.0001$). Also, T-score had a reverse and significant correlation with age of patients ($r = -0.280, P = 0.028$). The area under the curve (AUC) was 77%. Also, the sensitivity and specificity for the TCT level less than 4.37 mm (as cutoff point) was 100% and 39.1%, respectively. Conclusion: The findings of this study indicate that TCT has a direct significant correlation with the T-score obtained by the DEXA method. It has also been shown that TCT can be a relatively accurate diagnostic tool for predicting osteoporosis.

Keywords: Dual energy X-ray absorptiometry, osteoporosis, tibial cortical thickness

Introduction

Osteoporosis is characterized by reducing the bone density and bone microarchitecture deterioration, which itself leads to increased bone fracture risk. Reduction in density and bone mass occurs slowly and gradually, and most of its symptoms do not appear until the first fracture occurs. Ten million people worldwide are reported to have osteoporosis and 34 million suffer from osteopenia. It is also estimated that by 2020 almost 61 million people in the world will have osteoporosis or osteopenia. The high prevalence of osteoporosis-related fractures and mortality caused a heavy burden on the healthcare resources in recent decades. About 1.5 million bone fractures occur every year in the United States that cost $ 17 million. Women are at an 8x higher risk for osteoporosis than men, as the disease affects more than half of women over the age of 50 years. The findings of the Iran National Program for the Prevention, Diagnosis, and Treatment of Osteoporosis indicate that 70% of women and 50% of men over 50 years suffer from osteoporosis and osteopenia.

The identification of patients with osteoporosis has a particular importance in designing national supply plan and budget.

How to cite this article: Zadeh AF, Hanafi MG, Kiasat A, Mousavi M. Evaluation of the tibial cortical thickness accuracy in osteoporosis diagnosis in comparison with dual energy X-ray absorptiometry. J Family Med Prim Care 2019;8:523-7.
Bone mineral density (BMD) test is one of the simplest methods available to diagnose osteoporosis. BMD can be measured in a variety of ways including dual-energy x-ray absorptiometry (DEXA), CT scans (Osteo CT or QCT) of bones in the spinal column, wrist, arm, or leg, and quantitative ultrasound (QUS).[6] DEXA is the gold standard method and can be used to measure BMD anywhere in the body. But, in this method, usually only the density of the central bones, such as the spine and femur, is measured.[7] In addition, prescribing DEXA as an appropriate screening test for all menopausal women because of its difficulty and high cost is not feasible.[8]

In recent years, because of the increasing awareness and knowledge of the community, the familiarity of patients with the new methods of osteoporosis treatment, the health care systems have been encountered by increasing the population's demand for measuring BMD that requires a simple and inexpensive method for screening patients. Measurement of the mean cortical bone thickness (CBT) of the bones is a quick and accurate procedure to obtain information about bone quality.[9] Hence, We have aimed to evaluate the accuracy of tibial cortical thickness (TCT) in the diagnosis of osteoporosis compared with DEXA.

Materials and Methods

Study design
In this descriptive–analytic study, patients who referred to Imam Khomeini Hospital, Ahvaz from 2016–2017 were enrolled in the study for DEXA and knee X-ray. Patients under treatment with corticosteroids and/or immunosuppressive drugs, patients with hyperparathyroidism, liver disease, chronic diseases, prolonged immobility, and fracture history, and patient's systemic diseases (such as rheumatoid arthritis and lupus erythematosus symptoms) were excluded from the study. This study was approved by the Ethics Committee of Ahvaz Jundishapur University of Medical Sciences. All patients were signed informed consent.

Measurements
Data was collected for each patient including age, sex, radiography, and DEXA. The plain radiography of the anteroposterior (AP) views of the knee was carried out for all the patients. The total thickness of the tibia cortex (sum of the medial and lateral cortex) was measured using knee AP radiography at 10 cm from the proximal tibial joint. The mean of these two measurements was considered as the TCT. Measurement of BMD by DEXA method was performed using the Osteosys Dexum T and its measurements were reported as spine T-score. T-score was interpreted according to WHO criteria: T-score > −1 normal, −2.5 < T-score < −1 osteopenia and T-score ≤ −2.5 osteoporosis.

Statistical analysis
Descriptive statistical methods were used to calculate the mean and standard deviation. The data distribution was evaluated using the “D’Agostino and Pearson omnibus normality test” method. Accordingly, a comparison of data was done using analysis of variance (ANOVA) or Kruskal–Wallis test. Comparison of categorical variables was done by Chi-square. The receiver operating characteristic (ROC) curve and area under the curve (AUC) analysis was carried out to determine the optimal cutoff point for TCT to predict the osteoporosis. The AUC at 0.9 and above is considered to be excellent, whereas the AUC of 0.8–0.89 is good, 0.7–0.79 is fair, and below than 0.69 is considered as a poor diagnostic method.[10] Pearson correlation coefficient and simple linear regression were used to calculate the relationship between DEXA values and cortical thickness measurement. P value less than 0.05 was considered significant.

Results
In this study, 62 patients (90% female) were evaluated. The mean age of the patients was 57 years (range 45–80 years). Of these, 24 (38.7%) had osteopenia, 16 (25.8%) patients had osteoporosis, and 22 (35.5%) were normal. The mean TCT in the subjects was 3.98 mm [Table 1].

T-score had a direct and significant correlation with TCT level \(r = 0.51, P < 0.0001\) [Figure 1]. Also, T-score had a reverse and significant correlation with age of patients \(r = −0.280, P = 0.028\) [Figure 2]. Although TCT levels had an inverse correlation with age, this correlation was not statistically significant \(r = −0.161, P = 0.212\) [Table 2].

The level of TCT in different groups (patients with osteoporosis, osteopenia, and normal people) showed a significant difference \(P < 0.0001\). Multiple comparisons had shown that although the TCT level in normal people was significantly different from osteoporosis and osteopenia patients, this

| Table 1: Patients characteristics |
| --- |
| Statistics | Age | T-score | Tibial cortical thickness |
| Minimum | 45.00 | −5.700 | 2.020 |
| 25% Percentile | 49.00 | −2.600 | 3.503 |
| Median | 55.50 | −1.850 | 3.915 |
| 75% Percentile | 64.00 | −0.5750 | 4.483 |
| Maximum | 80.00 | 2.000 | 5.950 |
| Mean | 57.00 | −1.682 | 3.986 |
| Std. Deviation | 9.547 | 1.438 | 0.6997 |
| Passed normality test (alpha=0.05)? | No | Yes | Yes |

| Table 2: Correlation between variables of age, T-score and TCT |
| --- |
| Variables | Pearson Correlation (r) | Sig. (2-tailed) (P) |
| T-score Vs Tibial cortical thickness | 0.510** | <0.0001 |
| Age Vs Tibial cortical thickness: | −0.161 | 0.212 |
| T- Score Vs Age | −0.280* | 0.028 |
difference was not statistically significant among patients with osteopenia and osteoporosis [Figure 3].

The results of the ROC assessment showed that the AUC was 0.77 [Figure 4]. Also, the sensitivity and specificity for the TCT < 4.37 mm (as cutoff point) was 100% and 39.1%, respectively.

**Discussion**

Unlike public awareness around the world, osteoporosis is still underdiagnosed in most cases till bone fractures. Currently, the DEXA is the gold standard diagnostic method of osteoporosis, but unfortunately this method is not available in all diagnostic centers, especially in developing countries. Hence, proposing an available and inexpensive method for screening osteoporosis seems essential. Traditionally, the physician evaluates the trabecular pattern or cortical thickness of radiographic images for long bones before evaluating BMD by DEXA.[11] On the other hand, recent advances in digital technology have made it possible to accurately calculate the cortical thickness of the bones.[12] This caused the attention of researchers to evaluate the diagnostic value of cortical bone thickness (CBT) in predicting osteoporosis. For this purpose, Mather et al. showed that the cortical thickness of the humeral bone in a simple radiography has a strong association with the findings of DEXA.[12] Tingart et al. also showed that the humorous cortical thickness less than 4 mm strongly indicates a low BMD level.[13]
Contrary to the mentioned studies, we investigated correlations of TCT as a weight-bearing bone with T-scores, which is probably more accurately indicative of BMD. The findings of this study showed a direct significant correlation between TCT and T-score obtained from DEXA. In line with our results, Paterson et al. showed that the mean level of BCT in AP, lateral, and hindfoot alignment has a strong association with DEXA findings in the proximal femur, hip, and spine bones. Weber et al. also showed that the mean level of radial cortical thickness is significantly correlated with femoral (and not the lumbar spine) bone density. In addition, Sadat et al. also showed that there was a significant correlation between T-score with TCT and age. Similarly, our results also showed a significant correlation between age and T-score. This means that the increased age causes T-score decreasing. However, although there was an inverse association between age and TCT, this correlation was not statistically significant. It seems that the insignificance of this correlation is because of the relatively small sample size of this study.

In order to evaluate the accuracy of TCT value in predicting of osteoporosis, ROC analysis was performed. The AUC level was 77%, which indicates the acceptable accuracy of TCT in predicting osteoporosis. Weber et al. reported the AUC 74% for the BCT of 5.5 mm. This level is very close to our results, whereas they studied the cortical thickness of different bones.

Given the desirable diagnostic accuracy of TCT, cutoff points were determined for the osteoporosis prediction. As regards that the TCT assessment is proposed as an osteoporosis screening method, we have determined the cutoff point based on sensitivity level (and not specificity). We have considered the TCT < 4.37 mm as the cutoff, which at this point has a sensitivity of 100% and a specificity of 39.1%. Meanwhile, Patterson has selected the mean BCT of 3.5 mm in the distal tibia region in the AP as the threshold value for predicting osteoporosis, which has a sensitivity of 100%, specificity of 25%, a precision of 33%, a positive predictive value of 19%, and the negative predictive value was 100%.

In general, the findings of this study indicate that TCT has a direct significant correlation with the T-score obtained by the DEXA method. It has also been shown that TCT can be a relatively accurate diagnostic tool for predicting osteoporosis. The small sample size and the lack of anthropometric factors evaluation in order to eliminate the intervening variables were the limitations of this study.

Acknowledgements
We thank all our colleagues in Imam Khomeini hospital, Ahvaz, Iran.

Ethical standards
All procedures have been approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

Informed consent
Informed consent was signed prior to participation in the study.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

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