Tibial cortical thickness: A dependable tool for assessing osteoporosis in the absence of dual energy X-ray absorptiopmetry

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Abstract

Background and Objective: Bone mineral density measurements with absorptiometry dual-energy X-ray absorptiometry (DXA) is the gold standard for diagnosing low bone mass and risk for fragility fractures. DXA is not available at every center, and physicians require an alternative method of diagnosis before referring patients. We conducted this study to assess and compare total cortical thickness (TCT) and its relation to the T score by DXA and its correlation-ship in the diagnosis of osteoporosis. **Patients and Methods:** Total cortical thickness was carried out in 50 Saudi Arabian females ≥ 45 years with DXA scans and 25 patients with age of ≤ 35 years whose radiographs of the upper tibia were available for analysis. Postero-medial cortical thickness of the tibia was measured 13 cm from the joint line and an average was calculated. The average T score of the spine and the hip was taken. A comparison was made between age, T score, and the TCT. Inter cortical distance (ICD) was measured and compared in both groups. Data were analyzed for predictive value for diagnosis of osteopenia and osteoporosis. **Results:** There was a significant association between the T score and the TCT and age. As the age advanced the T score and TCT was very low (<0.05, 95% confidence interval [CI] <0.2). Forty patients were osteopenic and 10 osteoporotic. The T score in the former was -1.33 ± 0.71 and the later was -3.22 ± 0.56 ($P < 0.0001$ 95% CI: <-1.67) and the TCT was 0.655 ± 0.06 versus 0.51 ± 0.05 ($P < 0.0001$ 95% CI: <-0.17). In women ≤35 years the average TCT was 0.804 ± 0.155 cm and IMD was 3.34 ± 0.45 cm. **Conclusions:** We conclude that if TCT is less than the threshold value of ≤ 0.5 cm, patients should be referred for further investigations with DXA. We believe that further studies are needed to confirm our findings and in areas where DXA is not available, based on the TCT measurement anti-osteoporotic therapy could be initiated when other risk factors for osteoporosis is present.

Key words: Dual-energy X-ray absorptiometry diagnosis, osteoporosis, tibial cortical thickness

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Introduction

Low bone mass (Osteopenia and Osteoporosis) is common in the Saudi Arabian population, and dual-energy X-ray absorptiometry (DXA) is the gold standard for diagnosis of osteoporosis. DXA is still not available in many clinics, and even primary health care centers where majority of the elderly population go for their age-related ailments. As the DXA is unavailable many such patients with osteoporosis is missed and end up with fragility fractures, increasing the morbidity and mortality.

Before the evolution of the DXA, osteoporosis was diagnosed by way of plain radiographs, based on analysis of

the trabecular pattern in the upper femur and calcaneum or cortical thinning of metacarpals and long bones.[1-4]

Barnett and Nordin,[1] reported that accurate measurements can be made on standard radiographs of the femur, the second metacarpal bone and the spine. But for the long bones, medial and lateral cortices are thickest point, hence can be utilized.[5-7] Bloom[8] suggested that a combined cortical thickness at the humeral site was significantly superior to the metacarpal sites in the diagnosis of osteoporosis.

It is well established that weight bearing exercise increased bone mineral density (BMD) and cortical thickness[9] and studies have shown that influence of cortical bone on fracture risk is significant.[10-13] We believe that an assessment of cortical bone on a weight bearing long bone could be the ideal area to be assessed for predicting osteoporosis and fragility fractures. The objective of this study is to compare the total cortical thickness (TCT) and DXA and find any correlation exists.

Patients and Methods

The data collected for each patient included age, sex, radiographs and DXA records from the picture archiving and communication system (syngo.plaza - Siemens Healthcare, USA). Plain radiographs of the antero-posterior and lateral views of the tibia were available for analysis with DXA (Hologic, Waltham, MA, USA). Two measurements were taken of the medial and the posterior cortex of the tibia from 13 cm from the joint line with a precision of 0.1 mm [Figures 1 and 2]. The average of the two measurements was taken and termed as tibial cortical thickness. For the comparison, average measurements of T score of the Hip and spine were taken. Intra-cortical width and TCT was measured at 13 cm in the antero-posterior view in patients of ≤35 years who had a

preexisting radiograph of the tibia in the syngo.plaza - Siemens Healthcare, USA - System. ICD was measured in both groups at 13 cm from the top of the tibia.

Data analyses were performed with SPSS software, version 19.0 (SPSS, Chicago, IL, USA). TCT was plotted against average of DXA and Pearson correlation coefficients were obtained. Pearson correlation coefficients are reported to suggest the strength of the relationship between TCT and the average DXA.

Results

The average age of patients was 61.3 ± 10.2 years. Patients were divided into four groups ≤50, 51–60, 61–70 and over 70 years [Table 1]. There was a significant association between the T score and the TCT and age. As the age advanced, the T score and TCT was very low (<0.05, 95% confidence interval [CI] <0.2). Table 2 gives a comparison between the control group of patients ≤ 35 years and the study group ≥50 years. The difference between patients below ≤35 and ≥50 years was significant for both parameters at *P* value for TCT <0.001 CI 95% <0.2264 and IMW was <0.001 CI 95% <0.8233. Forty patients were osteopenic and 10 osteoporotic. The T score in the former was −1.33±±0.71 and the later was -3.22 ± 0.56 (*P* < 0.0001 95% CI <−1.67) and the TCT was 0.655 ± 0.06 versus 0.51 ± 0.05 (*P* < 0.0001 95%

Table 1: Comparison of TCT and T score between four groups

Groups	Number of patients	Mean age in years	Average T score	TCT in cm
Group I	5	51±2.3	−1.3±1.25	0.672±0.041
Group II	16	56.1±3.82	−1.52±0.86	0.63±0.06
Group III	20	64±3.2	−1.66±0.726	0.60±0.07
Group IV	9	79.22±5.5	−2.79±1	0.52±0.12

Between Group I and II: *P*<0.2, Group I and III: <0.05 95% CI<0.12; Group I and IV: *P*<0.05, 95% CI<0.2. TCT: Tibial cortical thickness; CI: Confidence interval
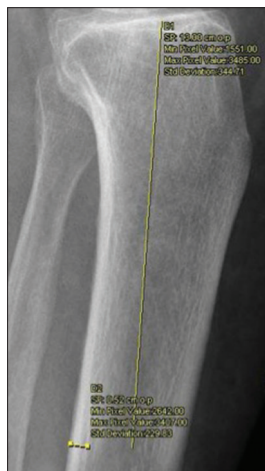

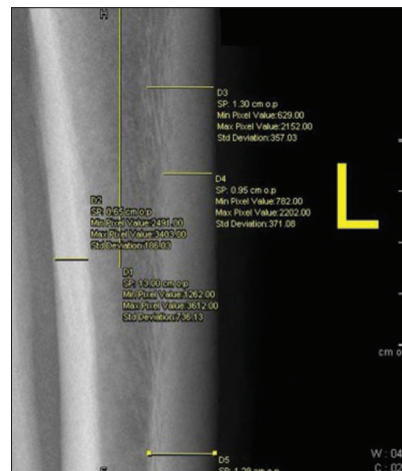**Figure 1:** Measurement of medial tibial cortical thickness

Figure 2: Measurement of posterior tibial cortical thickness

CI <−0.17) [Table 3]. Pearson correlation coefficients between the TCT values and the T scores by DXA showed the value of R was 0.77. This is a strong positive correlation, which means that high X variable scores go with high Y variable scores and vice versa. A value of R^2, the coefficient of determination was 0.59 [Figure 3].

DISCUSSION

Our study has shown that on the basis of plain radiographs of the tibia, a diagnosis of osteopenia and osteoporosis could be made easily. Despite global drive and growing awareness, osteoporosis remains under-diagnosed till it presents with fragility fracture. DXA remains the gold standard screening tool, but, unfortunately, it is not available in all the centers especially in developing the world. Hence there is a need of a way by which diagnosis of osteoporosis could be made, and treatment started and referred to centers where DXA is available. Prior to DXA scanning, physicians would rely either on analyzing trabecular patterns of proximal femur and calcaneum or cortical thinning of metacarpals and long bones.[1-4]

Table 2: Analysis of Tibial; Cortical Thickness and ICD between the patients ≤35 and ≥50 years

Parameters	≤35 years	≥50 years	P
Number of patients	25	50	
Average age	28.39±7.16	61.3±10.25	
IMW (cm)	2.65±0.34	3.34±0.45	<0.001 CI 95% <0.8233
TCT (cm)	0.804±0.155	0.605±0.07	<0.001 CI 95% <0.2264

Analysis of Tibial Cortical Thickness (TCT) and IMW between the patients ≤35 and ≥50 years. ICD: Intra Cortical Diatance; TCT: Tibial cortical thickness; CI: Confidence interval

Table 3: TCT in patients with osteopenia and osteoporosis

Number of patients	Age in years	T score	TCT in cm
40	59.38±7.86	−1.33±0.71	0.655±0.06
10	68.5±15.4	−3.22±0.56	0.51±0.05

P value for age<0.006 95% CI≤4.34, T score<0.0001 95% CI≤1.67 and for TCT *P*<0.0001 95% CI≤0.17. TCT: Tibial cortical thickness; CI: Confidence interval
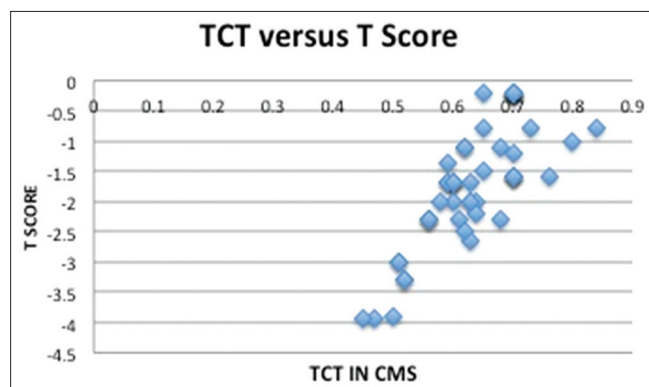

Figure 3: Pearson correlation coefficients between the total cortical thickness values and the T scores by dual-energy X-ray absorptiometry

Recent advances in digital technology with better precision had given rise to renewed interest in understanding the co-relation between cortical thickness. Mather et al.[14] measured cortical thickness of the proximal humerus in plain radiograph and found strong co-relation with DXA. Similarly, Tingart et al.[15] concluded measurement of cortical thickness of the proximal humerus is reproducible and a thickness <4 mm is highly indicative of low BMD.

In the current study, we select to study postero-medial thickness of the tibia as it is a weight bearing bone that should better correlate prediction of osteoporosis. Studies of El Maghraoui and Roux[16] on human subjects noted that the lumber and femur measures of osteoporosis may not fully represent osteoporosis in upper limb.

Our technique of cortical thickness measurement involves a combined thickness of posterior and medial cortex and dividing it with a mean diameter of the bone (calculated in antero-posterior and lateral view). It differs from the technique of Virtama and Telkka[2] as early as 1962, defined cortical index of humeral shaft as cortical thickness divided by bone diameter. They found a significant correlation between cortical index and bone density estimated from the dry weight of bone.

In the present study, Pearson correlation coefficients between the TCT values and the T scores by DXA showed a strong positive correlation. We found that if the TCT is <0.5 cm the chances of low BMD are very high. Interobserver and intraobserver measurement of TCT in our study showed excellent reliability and reproducibility. This may be attributed to the selection of posterior and medial cortex of tibia 13 cm distal to the knee joint line where cortex is homogenous, dense and well delineated due to stress of weight bearing.

Our study suggests that digital radiographs of elderly patients who visit clinics where DXA is not available a plain radiograph will be enough to diagnosis osteoporosis by way of TCT. TCT is a simple, reproducible and reliable adjunctive test and can be a useful test to stratify patients who may need further investigations for osteoporosis. Besides, this technique may help to understand the quality of bone and the information can be employed in preoperative planning of surgical technique and implant selection in trauma victims with fracture of lower extremity.

Importance of cortical thickness was first reported by Barnett and Nordin in the year 1960.[1] Meema and Meema[6] later found that, a combined cortical thickness (medial and lateral cortex) of the distal humerus below 6 mm was shown to be abnormally low and strongly indicative of osteoporosis. Cheung et al.[17] utilized peripheral quantitative computed

tomography scan to measure cortical thickness and found a significant co-relation with BMD.

Our study has few limitations as a pilot study there is a small number of patients belonging to the same ethnicity and defined geographical area. Secondly a larger prospective study is required for further validation. We conclude that if TCT is less than the threshold value of ≤ 0.5 cm, the likelihood of a significant decrease in bone density is very high, and such patients should be referred for further investigations with DXA. We further believe that more studies are needed in the future with large sample to confirm our findings, which could be implemented in routine use, in areas where DXA is not available.

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