

Cortical Thickness of Proximal Femur as a Preliminary Indicator of Bone Mineral Density

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ABSTRACT

Background: Osteoporosis progresses with advancing age. Estimation of bone mineral density (BMD) using dual energy X-ray absorptiometry (DXA) is valuable in predicting fracture risk in the elderly. DXA machines however may not always be available in under-resourced developing countries.

Aim: To find values of CTI and CFI in normal adult young and old, male and female population of Southern Punjab.

Study design: Cross-sectional population study

Methods: Measurements were recorded from 107 anteroposterior radiographs of proximal femur of normal adult male and female subjects divided in two groups: Young: 22 male and 26 females with mean age 28 ± 3.4 and Old: 31 male and 28 females with mean age 61 ± 5.2 .

Results: Statistical comparison between male and female subjects for CTI was not significant in the Y and O groups. Similar comparison for CFI while not significant in the Y-group was highly significant in the O-group. In overall comparison of Y and O groups the difference was very highly significant for CTI and CFI; both showing higher values in the Y-group.

Conclusion: CTI and CFI measured from radiographs of proximal femur are reliable parameters and can be recommended for preliminary assessment of bone mineral density in developing countries.

Keywords: Proximal femur, morphometry, cortical thickness index (CTI), canal flare index (CFI), bone mineral density

INTRODUCTION

Aging has its impact on skeletal tissue so that bones get osteoporotic with an increased risk of fracture in the elderly¹. Almost twenty percent men and fifty percent women may get a fracture; hip fracture being the most severe form². Increased porosity and thinning of the proximal femur leading to decline in bone strength are the major contributors. WHO recommends clinical assessment of osteoporosis by estimation of bone mineral density (BMD) using dual energy X-ray absorptiometry (DXA). For predictive value of BMD a fracture risk tool (FRAX) is also proposed³. DXA machines however may not always be available especially in under-resourced developing countries.

Patients presenting to the physician with a hip related disorder almost routinely undergo a hip joint X-ray. Preliminary assessment of BMD and fracture risk evaluation from radiographs in the absence of DXA can be beneficial and more practical in developing countries. The most common parameter in this regard is cortical thickness index (CTI) of the proximal femur. Although CTI remains the major determinant in this context CFI is also pertinent because it reflects on bone strength. Cortical flare index is usually used to classify the femoral canal and is a valuable tool helpful in selection of implant for total hip arthroplasty; it is also affected by aging^{4,5}. Significant correlation of CTI and CFI with BMD has been reported from various locations⁴⁻⁶. These studies however lack separate data for the two sexes.

Since no data on CTI and CFI and their relevance to BMD in Southern Punjab is available in the literature we decided to study the values of these indices in normal adult young and old, male and female population of Southern Punjab.

MATERIAL AND METHODS

After getting approval by the Ethical Committee for Medical research, this prospective cross-sectional population study was

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conducted at Multan Medical College Teaching Hospital, Multan during the period from March 2020 to August 2021. Individual patient consent was obtained.

Male and female adult subjects who volunteered or visited the hospital for some other reason and did not have any bony affection of the hip or a prior history of surgery in the region were included. They were divided into two groups: Young (Y-group) 25 to 35 years and Old (O-group) 55 to 67 years. Mean age for Y-group was 28 ± 3.4 years and for the O-group 61 ± 5.2 years. Y-group included 22 male and 26 females and O-group had 31 male and 28 females. Observations were recorded from 107 anteroposterior radiographs with a clear image of proximal femur.

Figure 1: Reference line at the level of tip of lesser trochanter, diameter at 2cm above the reference line (A), external diameter (B) and internal diameter (C) at the isthmus 10 cm below the reference line.



Measurements of cortical thickness were made as shown in Fig 1. A reference line was drawn horizontally at the level of tip of the lesser trochanter. All measurements were taken with reference to this line. Isthmus of the femoral canal was considered at 10 cm distal to the reference line.

Cortical thickness index (CTI) was calculated by subtracting internal diameter from external diameter and dividing the resultant by external diameter at 10 cm below the reference line i.e., B - C/B (Fig.1). Canal flare index (CFI) was defined as the width at 2cm proximal to the reference line divided by internal diameter at 10 cm below the reference line i.e., A/C

All observations were made by a single observer (MNC) and later independently reviewed by two investigators (MSA and FI). Results were tabulated and statistically analyzed using student t-test with significance at 95% CL.

RESULTS

The mean values±SD are shown in Table 1. Statistical comparison between male and female subjects for CTI was not significant in the Y and O groups. Genders' comparison for CFI while not significant in the Y-group was highly significant in the O-group. In an overall comparison of Y and O groups the difference was very highly significant both for the cortical thickness index and canal flare index; CTI and CFI both showing higher values in the Y-group.

Table 1: Mean values of cortical thickness index (CTI) and canal flare index (CFI) in the young (Y) and old (O) groups of male and female subjects and their statistical comparison

Groups			CTI			CFI		
			Value	p-value male vs female	p-value Overall Y vs O	Value	p-value male vs female	p-value Overall Y vs O
Y	Male	n= 22	0.61±0.04	0.0282	< 0.0001*	3.8±0.58	0.0278	< 0.0001*
	Female	n= 26	0.58±0.05			4.2±0.63		
	Overall	n= 48	0.60±0.04			4.1±0.71		
O	Male	n= 31	0.57±0.05	0.0408	< 0.0001*	3.8±0.64	0.0003*	< 0.0001*
	Female	n= 28	0.54±0.06			3.2±0.55		
	Overall	n= 59	0.56±0.05			3.6±0.46		

*Highly significant

DISCUSSION

Fractures of proximal femur are common in geriatric patients. Due to increased porosity, thinning of cortical bone and its density the strength is compromised. Surgical fixation with durable results in these situations is challenging ⁷. Therefore in everyday clinical practice prior assessment of bone mineral density is important and necessary in planning surgical fixation of geriatric hip fractures.

Sah et al⁸ in 2007 from their elaborate study on plain radiographs of proximal femur elucidated a significant correlation between CTI and BMD and proposed CTI as a simple, convenient and reliable instrument to assess bone mineral density. Since DXA machines are not available to the physician in most developing countries CTI remains a useful alternative for preliminary assessment of BMD. Another metric that can be helpful in decision making by the operating surgeon can be CFI because elderly people with their thin cortices have a lower CFI value as compared to the young⁹. CTI and CFI together may give a fair judgment of BMD and fracture risk in a patient.

In our study when an overall comparison of Y and O groups was made the difference was very highly significant both for the cortical thickness index and canal flare index; CTI and CFI both showing higher values in the Y-group. In This is due to increasing porosity of the bone with aging and is agreement with previous workers ^{6,9-12}. The value of CFI was significantly lower in the females of O-group as compared to the males indicating a wider canal with thin cortex. This is because osteoporosis with advancing age affects females more than the males^{2,11,12}. The implication is that males and females should be separately studied for BMD assessment in osteoporosis related issues.

CTI and CFI can be considered reliable parameters that can be measured easily on an anteroposterior radiograph of proximal femur. We recommend CTI and CFI as supportive tools for preliminary assessment of BMD where DXA is not available. Combined with other predisposing factors one can make a fair estimate of fracture risk in an individual case.

CONCLUSION

Cortical thickness index and canal flare indices measured from radiographs of proximal femur are reliable parameters and can be recommended for preliminary assessment of bone mineral density in developing countries.

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