ORIGINAL RESEARCH PAPER
Volume - 13 | Issue - 02 | February - 2024 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

# ASSESSMENT OF RISK OF OSTEOPOROTIC FRACTURES IN ELDERLY USING DIGITAL X RAY RADIOGRAMMETRY

Orthopaedics

**Dr. Deepak Mantri** Associate Professor,
**Dr. Jitendra Verma** Assistant Professor
**Dr. Ankit Thora** Assistant Professor
**Dr. Adit Agrawal** RSO Orthopaedics
**Dr Surya Prakash Garg*** Senior Resident *Corresponding Author

KEYWORDS

## INTRODUCTION

With the enormous population of India, that has now became the largest in the world, and the increasing mean population age, geriatric orthopedic issues are likely to become a significant concern. And with the high prevalence of Osteopenia (49.5%) and Osteoporosis (35.1%) in the Indian population, fragility fractures are likely to become a major healthcare issue.

Osteoporosis is defined as a Bone Mineral Density(BMD) T-score of less than -2.5, that is less than 2.5 standard deviations from the population mean Bone Mineral Density, as per the WHO. Whereas a BMD T-score between -1.0 and -2.5 is defined as Osteopenia.

The most common fragility fractures observed are those occurring in spine, wrist and hip. Osteopenia and Osteoporosis are frequently under-diagnosed in India, owing to a number of factors, the principal factors being a prohibitively high cost of the diagnostic tests for the same, the Dual Emission X-Ray Absorptiometry, I.e. DEXA scan, lack of the widespread availability of the DEXA scan and a lack of population awareness regarding the same.

Furthermore, some studies have shown that bone mineral density might not be the best predictor of fragility fractures as it is measured on trabecular bone and that the quality of cortical bone may be a better predictor.

There are other modalities available for the diagnosis of Osteoporosis, namely Radiogrammetric parameters, heel quantitative Ultrasound and peripheral quantitative Computed tomography (pQCT).

Of these, pQCT suffers the same shortcomings as DEXA scan,i.e., a lack of widespread availability and a high cost of the investigation while also delivering a higher radiation dose. Heel quantitative ultrasound is an operated dependent procedure and being relatively new lacks definite reference values. Thus making these options non-viable in the Indian economy.

Several radiogrammetric parameters have been defined each relying on a different part of the skeleton. They are based mainly on the thickness of cortical bone at a predetermined level of long bone diaphysis, but there is lack of consensus regarding which of these parameters is the most suitable for widespread use. We selected three parameters for our study. The first being Deltoid tuberosity Index (DTI) measured in the proximal humerus AP Radiograph, just proximal to the Deltoid Tuberosity, as a ratio of outer to inner diameter of the shaft.

The second index used was the Cortical thickness Index (CTI)[9] measured in the proximal femur, 8 cm distal to the lesser trochanter (LT), as a ratio of the difference between the outer and inner diameter to the outer diameter [(Do-Di)/Do].

The third and final index we used was the Distal Femoral Cortical Index(DFCI)[24] calculated at the level the inner and outer cortices become parallel to each other and is the ratio of the outer to inner diameters.

With this study, we compared the Deltoid Tuberosity Index, the proximal femur Cortical Thickness Index and the Distal Femoral Cortical Index to find which is the most reliable of these parameters.

## MATERIAL AND METHODS

We conducted our study in a tertiary care centre in central India, over a period of 1.5 years from October 2020 to April 2022.

A written, informed consent was obtained from all participants authorizing the radiographs and documentation. The sample size for the study was calculated using standard formula and a 10% error rate, and a final sample size of 144 was used.

For inclusion in our Osteoporotic group, patients of age more than 60 years with Per-trochanteric neck of femur fracture following trivial trauma (severe osteoporosis as per NICE guidelines[xiv] were selected. And we compared these to the second group of normal bone density individuals between the ages of 18 and 30 years who presented with other trauma to the casualty or OPD and who consented for X Rays.

All patients having any cause for pathological low bone density were excluded from our study like-

1. All the patient with any chronic disease affecting the bone quality, like, uncontrolled diabetes Mellitus, paralytic disorders, chronic liver diseases, chronic kidney diseases, malabsorption syndromes, nutritional deficiencies,
2. Patients on prolonged steroid therapies, anti-tumour drugs, etc.
3. Patients with Bone Pathologies like bone tumors, etc.

### Methods for the Radiographs

For the study, we focused on 3 radiological views, of 3 different anatomical regions, all done on the un-injured limbs.

The first is the Antero-Posterior radiograph of the shoulder joint with humerus in 15 degree external rotation making the deltoid tuberosity visible in its full profile.(Picture 1) This view was used for the measurement of the Deltoid Tuberosity Index Calculated just proximal to the Deltoid tuberosity as a ratio of the outer and inner cortical thickness.[8]

### DTI = Outer Cortical thickness/ Inner Cortical Thickness

The second xray we used is that of the hip joint with femur in 15 degree internal rotation to make the Lesser Trochanter visible. (Picture 2)On this radiograph we drew a line of 8 cm along the long axis of the femur extending dismally from the level of the Lesser Trochanter. The cortical thickness was measured at the distal end of this line. The calculation for the Cortical Thickness Index was done using the Inner and Outer Diameter of the Shaft of femur at this level as follows:[7]

### CTI = (Outer Diameter - Inner Diameter) / Outer Diameter

The third Radiograph we used was the Standard Antero-Posterior Radiograph of the Knee joint with at least the distal third femoral shaft visible.(Picture 3) The level for the cortical thickness measurement was decided by the level at which the inner and outer cortices become parallel to each other. The Distal Femoral Cortical Index was calculated as a ratio of the outer and inner diameters of the shaft

perpendicular to the long axis of the femur at the above described level.[28]

**DFCI = Outer Diameter / Inner Diameter**

For this study, we used the above described indices, namely the Deltoid Tuberosiy Index, the proximal femur Cortical Thickness Index and the Distal Femoral Cortical Index (DFCI), and compared the data we obtained using ROC (Receiver Operating Characteristic) Curve to find the cut-off values. We also used the Kappa Value and Spearman Correlation Coefficient to compare the predictive value of the indices.

## RESULTS

In our study, we had a total of 144 individuals, with 73 in the osteoporotic group and 71 in the normal group.

Of the ones in osteoporotic group, 34 were females and 39 were males and in the normal group, 34 were females and 37 were males. Using the Pearson Chi-Square test and calculating the p-values, we found no significant difference in the two groups indicating a uniform distribution among the study groups.

The mean values for the osteoporotic group for DTI, CTI and DFCI were 1.46, 0.46 and 1.69 respectively, whereas for the normal group, they were 1.82, 0.56 and 2.45 respectively. The difference in all the three indices among the two study groups were significant with p-values of less than 0.01 in all the three indices. (Table 1)

To find the validity of these parameters we plotted the Receiver Operating Characteristic (ROC) curve to check their usefulness in discriminating between the osteoporotic and non-osteoporotic individuals.(Picture 4)

Calculating the area under the ROC curve, the area if more than 0.9 indicating an excellent result, all the three indices had an area of over 0.9, the DTI being 0.937, the CTI being 0.92 and the DFCI being 0.96, all showing excellent result. (Table 2)

The standard error of the DTI was 0.021, for CTI it was 0.022 and for the DFCI it was 0.016.

For the cut-off value calculations, the results we got were as follows: (Table 3)

Here, the highest sensitivity was shown by DFCI with a cut-off value of 93.20%, with DTI and CTI both showing equal sensitivities of 91.80% with respective cut-off values being 1.61 and 0.546.

DFCI also had the highest specificity with 88.70% and DTI being 85.90% and CTI with 76.10%.

## DISCUSSION

Osteoporosis is a frequently under-diagnosed disease, simply owing to the fact that it is asymptomatic, causes no direct disability and requires dedicated tests in the form of DEXA or pQCT, both of which are difficult to justify based on their high cost and their lack of a widespread availability.

With Digital X Ray Radiogrammetry, all of these problems can easily be solved as digital X Rays are available even in remote areas and are vastly more affordable than both DEXA and pQCT.

For our study, our total study group was of 144 patients comprising both Osteoporotic and Normal Individuals. Of these, 73 were in the osteoporotic group and 71 were in normal group.

In the Osteoporotic group, 34 were females and 39 were males indicating a roughly equal distribution among both the genders. We had a similar sex ratio in the normal group of 71 patients with 34 females and 37 males, both genders being roughly equal.

Comparing the sex ratio in both the groups, we found the p-value to be 0.87 indicating that the statistical difference among the two groups was insignificant.

In our study, we found that the Deltoid Tuberosity Index had a mean value of 1.46 with a standard deviation of 0.12 in the osteoporotic group (N=73) and the mean was 1.82 with a standard deviation of 0.19 in the normal group (N=71), with the p value of less than 0.001. We also concluded that the DTI can give us a 91.80% sensitivity and 85.9% specificity in the diagnosis of Osteoporosis when using a cut-off value of 1.61. The Area Under the Receiver Operating Characteristic (ROC) curve for the DTI was 0.937 indicating that it is an excellent test for the diagnosis of the disease.

In 2015, Spross, et al,[8] defined the Deltoid Tuberosity Index (DTI) and found this to be a simple and reliable way to discriminate between the patients suffering from osteoporosis and those not.

The DTI was further compared to 2 other indices in the proximal humerus X Ray in a 2020 study conducted by Jain S, et al.[26] and it was found out to be the best parameter in the proximal humerus AP X Ray with a very high sensitivity and specificity.

Overall, the DTI can be a very good screening test for the diagnosis of Osteoporosis and can be helpful in many different scenarios.

With our study of 144 patients, we found the mean value of CTI to be 0.46±0.075 in the Osteoporotic group whereas in the Normal group it was 0.56±0.037 with a p value of <0.001 showing that it is a valuable marker. Also, with a cut-off value of 0.546, it gives us a 91.80% sensitivity and 76.10% specificity. Area under the ROC curve for CTI was 0.923 showing that it is also an excellent screening test, albeit with a lower specificity.

In 2018, Nguyen Bao NT, et al., conducted a study to compare 2 radiogrammetric indices of the proximal femur, namely the Cortical Thickness Index (CTI) and the Canal Flare Index (CFI). With a sample size of 560 volunteers and a p-value of <0.001, they found that the CTI was a reliable and accurate predictor of Osteoporotic status and of the Osteoportic Fracture risk with DTI being superior to the CFI.

A similar index, the Femoral Cortical Index was studied by Feola M., et al., in 2015 with a group of 152 patients of fracture neck of femur. They concluded that the FCI had good correlation to fragility fractures and can be useful in predicting the osteoporotic fractures.

We compared the DFCI in a total of 144 patients divided roughly equally among those with and those without osteoporosis. The mean value in those with osteoporosis was found to be 2.45 with a standard deviation of 0.34, whereas, the mean value of the DFCI in those without osteoporosis was 1.69 and had a standard deviation of 0.23. The p-value for the difference in the means of these 2 groups was less than 0.001 indicating a statistically significant difference. It can give us a 93.20% sensitivity and a specificity of 88.70% when using a cut-off value of 2.079 to diagnose the disease. The area under the ROC curve was found to be 0.96 making it an excellent test to assess significant osteoporosis.

Distal Femur Cortical Index (DFCI), described in the 2018 study by He Q-F, et al.,[28] compared 2 parameters in the distal femur AP radiograph, namely, the average Cortical Bone Thickness (CBTavg) and the Distal Femoral Cortical Index (DFCI). They had a total of 361 patients in their study and they concluded that the DFCI was easier to calculate and had better reliability than the CBTavg.

Comparing the 3 indices with respect to the data we had in our study, The mean values of the DTI, CTI and the DFCI were 1.82, 0.56 and 2.45 in the Normal individuals respectively whereas the for the Osteoporotic groups the mean values were 1.46,0.46 and1.69 respectively. For all these three indices, we found significant difference in the two study groups, the p-value being less than 0.01 in all the three cases.

Plotting the Receiver Operating Characteristic curve, the DTI had a Area Under the Curve(AUC) of 0.937, the CTI had a 0.923 and the DFCI had the highest with a AUC of 0.961, showing that all the three have excellent validity in discriminating between the osteoporotic and non-osteoporotic groups.

The cut-off value calculations gave us a 91.8% sensitivity and 85.90% specificity for the DTI with a cut-off value of 1.61, 91.80% sensitivity and 76.10% specificity for the proximal femur CTI using 0.546 as the cut-off value and for the DFCI when a cut-off value of 2.079 was employed, it gave us a sensitivity of 93.20% and a specificity of 88.70% and thus also the highest Youden's Index.

We tried finding studies comparing these indices directly but we didn't find any such studies.

And so, out of the 3 parameters we had, the Distal Femoral Cortical Index shows the highest sensitivity and specificity making it a more reliable tool for evaluating osteoporotic fracture risk in the old and frail.

We found that the Deltoid Tuberosity Index (DTI), the Cortical Thickness Index of proximal Femur (CTI) and the Distal Femoral Cortical Index (DFCI), are all very good screening tests for severe osteoporosis. They can prove invaluable to the modern orthopaedic practice by giving us an idea about the patients' bone quality on a single, cheap, digital X Ray. It will be useful in a very wide scope ranging from the remote areas with a lack of modern investigations to the tertiary care centres with a whole spectrum of patient benefit ranging from the earlier diagnosis of osteoporosis facilitating a prophylactic therapy for the same to improving the quality of implant used in management of fractures or bone pathologies by providing a quick assessment of the target bone.

## SUMMARY AND CONCLUSION

Osteoporosis is a very prevalent disease and being asymptomatic, with the primary manifestation being pathological fractures, it largely goes under-diagnosed and under-treated.

The diagnosis can be done by various methods like pQCT, USG-BMD, or the current gold standard DEXA scan. While effective, each method has some limitation of the other. Further, these methods lack in that they do not consider cortical thickness among the assessed parameters, which, according to some recent studies, might be a better indicator for osteoporotic fracture risk than bone porosity itself.

Besides, both the DEXA and pQCT scan analysis requires specialized equipment which is very rarely available in tier-2 and tier-3 cities, making the diagnosis of this widespread disease impossible.

DXR is done on simple digital X Rays which is both widely available even in the remotest areas and far more affordable. And, by the virtue if all these parameters being ratios, the requirements for standardization of the X Ray equipment and magnification are completely eliminated. The analysis of the X Rays for DXR is also straight-forward, and the values obtained are reliable and observer independent making the diagnosis of osteoporosis much more accessible to distant areas.

We compared 3 radiogrammetric parameters that use cortical thickness as a primary marker and can be easily done on standard digital radiographs.

The 3 indices used here, namely Deltoid tuberosity Index (DTI), Cortical Thickness Index (CTI) and Distal Femoral Cortical Index (DFCI), all showed a sensitivity of more than 90% and specificity of more than 75% and thus are valid tools for assessing the osteoporotic fracture risk and can be vital screening tools to help make the diagnosis of osteoporosis more accessible and affordable.

Of these 3, the Distal Femoral Cortical Index had the highest sensitivity(93.20%) and specificity(88.70%) and thus it is the best among the aforementioned radiogrammetric parameters.

These parameters can be used as a screening tool for high risk of fragility fractures and thus prove invaluable in starting prophylactic treatment reducing the healthcare burden of fragility fractures.

They can also be useful in guiding the treatment of fracture patients by improving the choice of surgery and implant and also the ultimate outcome of the treatment.

## REFERENCES


1. United Nations, World Population Prospect, 2022,https://population.un.org/wpp/
2. Marwaha, R.K., Tandon, N., Garg, M.K. et al. Bone health in healthy Indian population aged 50 years and above. Osteoporos Int 22, 2829–2836 (2011).
3. Sheu A, Diamond T. Bone mineral density: testing for osteoporosis. Aust Prescr. 2016 Apr;39(2):35-9.
4. Tsuda T. Epidemiology of fragility fractures and fall prevention in the elderly: a systematic review of the literature. Curr Orthop Pract. 2017 Nov;28(6):580-585.
5. Shaki O, Rai SK, Gupta TP, Chakrabarty BK, Negi RS. To study the awareness of osteoporosis in postmenopausal Indian women in a Northeast part of India: An evaluation of the Osteoporosis Health Belief Scale. J Family Med Prim Care. 2021 May;10(5):1950-1955.
6. Bell, K. L., & Loveridge, N. (1999). Intracapsular hip fracture: increased cortical remodeling in the thinned and porous anterior region of the femoral neck. Osteoporosis International, 10(3), 248-257.
7. Stagi, S., Cavalli, L., Cavalli, T. et al. Peripheral quantitative computed tomography (pQCT) for the assessment of bone strength in most of bone affecting conditions in developmental age: a review. Ital J Pediatr 42, 88 (2016).
8. Spross C, Kaestle N, Benninger E, Fornaro J, Erhardt J, Zdravkovic V, Jost B. Deltoid Tuberosity Index: A Simple Radiographic Tool to Assess Local Bone Quality in Proximal Humerus Fractures. Clin Orthop Relat Res. 2015 Sep;473(9):3038-45.
9. Hajian-Tilaki K. Receiver Operating Characteristic (ROC) Curve Analysis for Medical Diagnostic Test Evaluation. Caspian J Intern Med. 2013 Spring;4(2):627-35.
10. He QF, Sun H, Shu LY, Zhu Y, Xie XT, Zhan Y, Luo CF. Radiographic predictors for bone mineral loss: Cortical thickness and index of the distal femur. Bone Joint Res. 2018 Aug 4;7(7):468-475.
11. Feola, M., Rao, C., Tempesta, V. et al. Femoral cortical index: an indicator of poor bone quality in patient with hip fracture. Aging Clin Exp Res 27 (Suppl 1), 45–50 (2015).
12. Sözen T, Özışık L, Başaran NÇ. An overview and management of osteoporosis. Eur J Rheumatol. 2017 Mar;4(1):46-56.
13. Miller PD. Underdiagnosis and Undertreatment of Osteoporosis: The Battle to Be Won. J Clin Endocrinol Metab. 2016 Mar;101(3):852-9.
14. Zhuang, H., Li, Y., Lin, J. et al. Cortical thickness in the intertrochanteric region may be relevant to hip fracture type. BMC Musculoskelet Disord 18, 305 (2017).