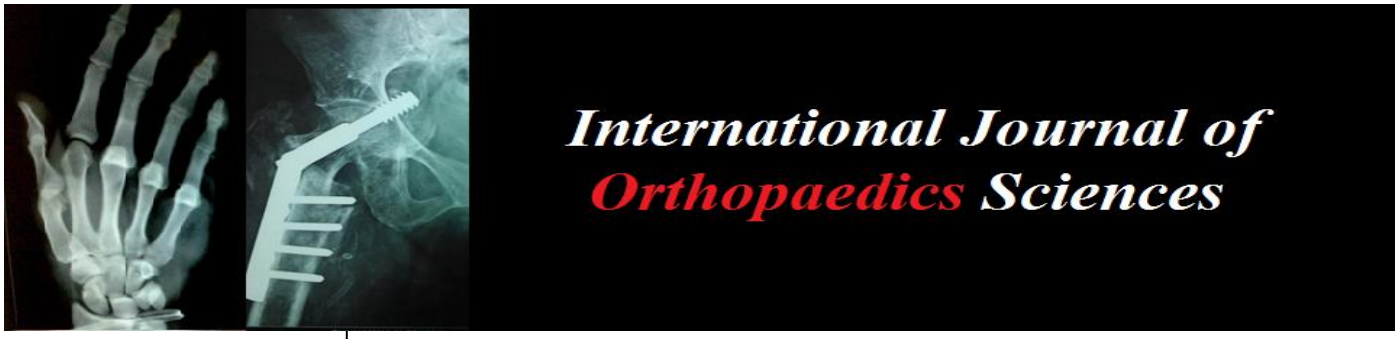

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Dr. Utkarsh Burli
Post-Graduate, Department of Orthopaedics, KAHER, JNMC Belagavi, Karnataka, India

Dr. Kiran S Patil
Professor, Department of Orthopaedics, KAHER, JNMC Belagavi, Karnataka, India

Dr. Puneet H Chamakeri
Assistant Professor, Department of Orthopedics, KAHER, JNMC Belagavi, Karnataka, India

Dr. Anmol Rajeev Mittal
Post-Graduate, Department of Orthopaedics, KAHER, JNMC Belagavi, Karnataka, India

Corresponding Author:
Dr. Anmol Rajeev Mittal
Post-Graduate, Department of Orthopaedics, KAHER, JNMC Belagavi, Karnataka, India

Reliability of radiological indices in comparison with dual energy x-ray absorptiometry in diagnosis of osteoporosis: A cross-sectional study

Dr. Utkarsh Burli, Dr. Kiran S Patil, Dr. Puneet H Chamakeri and Dr. Anmol Rajeev Mittal

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Abstract
Background: Osteoporosis projects a dominant issue related to health in the community in developing country like ours –India and is often unrecognised or undiagnosed. Early Diagnosis and treatment of osteoporosis is of utmost importance. This study evaluates the accuracy of Radiological Indices in comparison to gold standard DEXA scan for diagnosis of osteoporosis, so that diagnosis of Osteoporosis can be done using simple radiographs which would be cost effective and less exposure to radiation.
Methods and Material: The is study is a one year hospital based comparative study which included a total of 80 patients who presented to OPD / IPD of Department of Orthopaedics and met the inclusion criteria were enrolled in the study. Patients were subjected to DEXA scan and a plain radiograph of either of the hip joint with full length femur in AP and Lateral views. Subsequently, the Singh's Index, Cortical Thickness Index(CTI) AP and Lateral, Calcar to Canal Ratio (CCR) were measured and compared with the standard DEXA scan.
Statistical analysis used: Spearman's Rank co-efficient was used to find correlation between Radiological Indices and DEXA scan, Kappa Statistics for level of agreement, Sensitivity and Specificity for Radiological Indices was calculated.
Results: The data analysed showed significant correlation (Spearman co-efficient) between Radiological Indices and DEXA scan. Cortical thickness index Antero-posterior view and Lateral view with cut-off 0.43(r=0.8172, p< 0.0001 and r=0.8243, p< 0.0001 respectively), calcar to canal ratio with cut-off 0.50 (r=0.8188, p< 0.0001). Similarly for Singh's Index (r=0.6002, p< 0.0001).
Conclusion: Radiological indices are reliable in the diagnosis of Osteoporosis and have a good correlation with T scores decuded by DEXA scan.

Keywords: Osteoporosis, DEXA scan, radiological indices, cortical thickness index

Introduction
Osteoporosis is a regularly noticed disorder of the osseous skeletal system occurring in the geriatric age and is often unrecognised or undiagnosed. It projects a dominant issue related to health in the community in developing country like ours –India [1]. In the most populous countries like China and India, the majority of the population lives in rural areas, where hip fractures are often treated conservatively at home instead of by surgical treatment in hospitals. About 30-50% women and 15-30% men are suffering from osteoporosis all over the world in a given time. In India, the highest incidence is at 50-60 years of age, when compared to western countries it is around 70-80years [2]. By year 2050, it is expected that the hip fractures as a resultant of osteoporosis would exceed six million. In a study among Indian women aged 30-60 years from low income groups, BMD at all the skeletal sites were much lower than values reported from developed countries, with a high prevalence of osteopenia (52%) and osteoporosis (29%) thought to be due to inadequate nutrition [2]. A study by John *et al*. in New york, done for determination of the correlation of radio-morphometry to the severity of osteopenia as deduced by Total body neutron activation analysis and photon absorptiometry. The radiographic techniques used were Metacarpal index, the femoral score, total peripheral score, biconcavity index, femoral trabecular pattern. It revealed there was a remarkable correlation among the regional bone mass ratio and metacarpal index and femoral score.

The correlation was better for total peripheral score [3]. Similarly, Lopamudra *et al* studied plain X-ray films of pelvis of 168 patients to anticipate risk of getting an fracture due to low mineral density of bone using morphometric parameters of femur-proximal end. He analysed neck shaft angle of femur, axis length of hip, axis length of neck of femur and compared with the DEXA T Score of femur neck. It was found that there is a very good correlation with neck of femur bone density and morphometric characters of femur – proximal end [4].

DEXA Scan is the best known, unambiguous and meticulous modality to measure the bone mineral density known by far till date [1]. The fracture risk can be assessed by clinical evaluation of risk factors and by evaluation of mass of bone by radiological parameters. In the present study, the Radiological indices *viz*. Cortical Thickness Index (CTI) in AP/Lateral, Calcar to canal ratio (CCR), Singh's Index were compared to gold standard DEXA scan, so as to ensure its reliability in diagnosis of Osteoporosis.

Material and Methodology

Data was collected from all patients above 50 years age, who presented to Orthopaedics OPD or admitted under Orthopaedics department of KLE's Dr. Prabhakar Kore Hospital and MRC. A total of 80 Patients were selected willing to enrol in the study and fulfilling the eligibility criteria after an written informed consent. The institution ethical committee approved the study protocol. Patients on medication that interfere with calcium metabolism and homeostasis and Patients with chronic diseases were excluded from the study.

The patients were subjected to DEXA scan (GE Wipro and 2008 Lunar model). Scan is conducted over two sites the lumbar spine followed by Bilateral hip joint and further underwent plain radiograph (Digital radiograph) of either of the Hip joints with full length femur in two perpendicular plane (Antero-posterior and lateral). The X-ray tube was placed 1metre away from the cassette. The calcar to canal ratio, cortical thickness index (both in AP & Lateral) and the Singh's Index was measured. BMD data obtained from the gold standard DEXA Scan (T score < -2.5 defined as osteoporosis by WHO) is compared with the radiological indices values obtained by plain radiographs of hip joint with full length femur namely Singh Index (Figure 1), Calcar to canal ratio (Figure 2a) and CTI (Ap/Lateral) (Figure 2b).

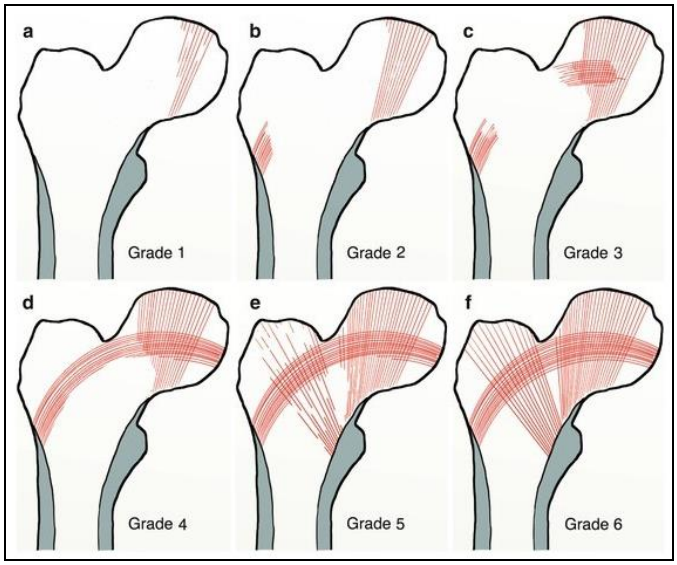
Figure 1: Singh's Index (Ref: Kanakaris N.K., Lasanianos N.G. (2015) Singh Index for Osteoporosis. In: Lasanianos N., Kanakaris N., Giannoudis P. (eds) Trauma and Orthopaedic Classifications. Springer, London)

Figure 2a and 2b: (1) Calcar canal ratio and (2) Cortical Thickness (Ref: Yeo, A.K.S., Ahrberg, A.B., Theopold, J.D. *et al*. Are radiographic indices reliable indicators for quantitative bone mineral density and vitamin D status after femoral neck fractures? A retrospective study in 112 elderly patients)

Results

The study included 80 patients with the mean age of 62 years (range 50-89). Out of these 80 patients, 36 were osteoporotic (T score below -2.5) and 52.83% were women. There was a significant correlation between the radiological indices and DEXA scan by Spearman's correlation co-efficient and moderate level of agreement for Singh Index and substantial level of agreement for rest of the indices was observed for intra-observer reliability using Landis and Koch Kappa statistics (Table 1). All the indices measured were significantly different for osteoporotic and non-osteoporotic patients. A cut-off value of 0.43 and 0.50 for CTI(Ap/Lateral) and CCR respectively showed presence of Osteoporosis with 100% sensitivity for all indices and Specificity of CTI(Ap)-74.58%, CTI(Lateral)-78.57% and CCR-75.86% (Table 2).

The sex predilection of Osteoporosis was tested using the Chi-Square test, and it was to be significant with a P value of 0.048, Suggesting that the females are more prone for Osteoporosis. In the present Study out of 36 Osteoporotics, 28 were women and 8 were men and the women contributing to 52.83% of Osteoporotics (Table 3). Significant correlation was found between DEXA scan and all the radiological Indices evaluated in this study. Singh's Index Shows Moderate level of agreement and the rest of the indices Show Substantial level of agreement according to Landis and Koch Kappa Statistic Criteria [5]. An agreement is graded as slight (kappa=0-0.2), fair (kappa=0.21-0.40), moderate (kappa=0.41-0.60), substantial (kappa=0.61-0.80) and almost perfect (kappa=0.81-1).



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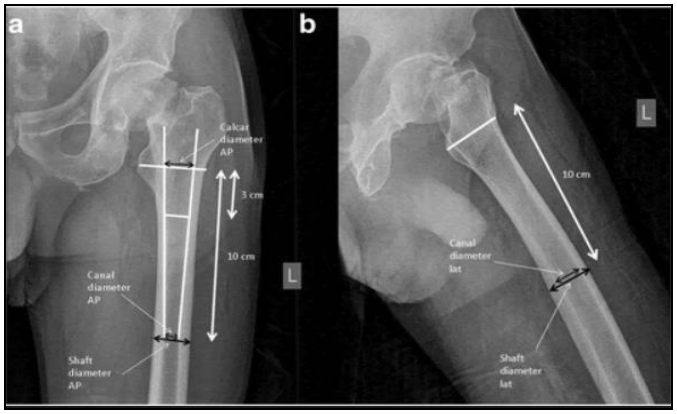

Fig 2: (1) Calcar canal ratio and (2)Cortical Thickness (Ref: Yeo, A.K.S., Ahrberg, A.B., Theopold, J.D. *et al*. Are radiographic indices reliable indicators for quantitative bone mineral density and vitamin D status after femoral neck fractures? A retrospective study in 112 elderly patients)

Discussion

Osteoporosis is most frequently and commonly encountered in daily routine practice and is more so seen in geriatric age group. It is usually left undiagnosed or unrecognised in the peripheral setup and projects a huge burden to the community in India.

In this study, our primary aim was to evaluate the reliability of radiological indices namely Singh Index, cortical thickness index (CTI) AP and Lateral, Calcar to canal ratio in comparison with the benchmark standard Dual –Energy-Xray –Absorptiometry in the diagnosis of Osteoporosis. The CTI (AP) cut off value for osteoporotic was 0.43, sensitivity for CTI (AP) was 100%, specificity was 74.58%. The positive predictive was 58.33% and negative predictive value was 100%. There correlation with DEXA scan T- score and the CTI (AP) was measured using the spearmen correlation co-efficient (*r=0.8172, p*< 0.0001) showed a substantial correlation of CTI (AP) with DEXA scan and also had a significant level of agreement (kappa=0.6063). Similarly, the mean CTI (lateral) cut off value for osteoporosis was 0.43, sensitivity was 100%, specificity was 78.57%. The positive predictive value was 66.67% and negative predictive value was 100%.CTI(lateral) also had a substantial level of agreement (kappa=0.6875). There was a strong correlation between CTI (lateral) and DEXA T score with Spearmen co-efficient (*r=0.8243 p*< 0.0001).

The cut off value for calcar to canal ratio for diagnosing osteoporosis was 0.50, sensitivity was 100%, specificity was 75.86%, positive predictive value was 61.11% and negative predictive value was 100%. Here also there was a significant correlation with DEXA T- score on evaluation with Spearman co-efficient (*r=0.8188, p*< 0.0001) and a significant level of agreement (kappa=0.6335).

In contrast, to study done by Sah *et al*. with cut off value of CTI(AP) was 0.50, CTI(Lateral) was 0.40 [6], and study done by Andy K.S. Yeo *et al*. the CTI(AP) and CTI(lateral) cut off was 0.40, Our study showed cut off value of 0.43 for both CTI(AP) and CTI(lateral). This might be due to the different characteristics of the patient as the other studies were done in western countries and also the mean age in our study was comparatively less than in others studies i.e. 61 years whereas in other studies it was 67 years and 79 years respectively. The patients in these studies might have an established bone mineral loss and osteoporosis, also the patient had hip fractures and this fracture might have altered the density of the bone at the femur neck [7].

In the studies mentioned above it was concluded that the calcar to canal ratio had no significant correlation with the DEXA T- scores, but the present study showed a significant correlation with a cut off value of 0.50 and a specificity of 75.86% and spearman co -efficient of *r=0.8188, p*< 0.0001. This might be due the difference in the long bone morphometric, bone mineral density, genetic factors etc. of the western individuals to that of the Indian population.

There has always been a great argument and dispute regarding the reliability of use of Singh Index in establishing Osteoporosis. Sah *et al*. in his concluded that there is no significant correlation between Singh Index and DEXA scan [6]. Similarly, Hitesh Vora *et al*. study revealed that there was no significant correlation and had a fair level of agreement with kappa=0.348 and concluded that the Singh Index is not reliable [8].

In contrast, Study done by Deeptiman James *et al*, suggested that Singh Index is reliable and can be used for screening of Osteoporosis [9], also in a study done by Sandeep Krishna A. *et al*. assessed the Singh Index by Plain radiogram using digital Xray system. This study revealed a significant correlation with DEXA Scan with Sensitivity of 68.42% and specificity of 83.33% [10]. This significance may due to clearer X-ray films due to Digital radiography compared to conventional radiographs in which the trabecular pattern may be masked due to fat overlap and also single observer leading to bias.

According to the present study, the Singh Index showed significant correlation with DEXA T scores with sensitivity of 72.22% and specificity of 86.36%. In this study also, digital Xray was used and a single Observer with moderate level of agreement (kappa=0.591).

Table 1: Kappa, Spearman correlation and p value statistics between DEXA Scores and the following for the assessment of level of agreement for Intra-observer reliability

Radiological indices	Kappa Value	R	p value
Singh's index	0.5918	0.6002	<0.0001
Cti (ap)	0.6063	0.8172	<0.0001
Cti (lateral)	0.6875	0.8243	<0.0001
Ccr	0.6335	0.8188	<0.0001

CTI: Cortical Thickness Index
CCR: Calcar Canal Ratio
R: Spearman Correlation

Table 2: Cut off Values for Osteoporosis, specificity and sensitivity of Radiological Indices and their mean in osteoporotic and non-osteoporotic groups.

Radiological indices	Cut-off value	Specificity	Sensitivity	Osteoporosis		Non-osteoporosis	
				Mean	S.D.	MEAN	S.D.
AP(CTI)	0.43	74.58%	100%	0.43	0.03	0.55	0.07
Lateral (CTI)	0.43	78.57%	100%	0.43	0.04	0.55	0.06
Calcar Canal Ratio	0.50	75.86%	100%	0.50	0.04	0.62	0.06

Table 3: Distribution of osteoporosis based on sex.

Sex	Number	%	OP	%	NO OP	%
Female	53	66.25	28	52.83	25	47.17
Male	27	33.75	8	29.63	19	70.37

OP: Osteoporosis
%: Percentage

Overall, the findings in the study show good correlation between the T scores as established by DEXA scan and the radiological indices, suggesting its application and use in the diagnosis of osteoporosis. There exists however, a possibility of observer bias owing to it being a single observer study.

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