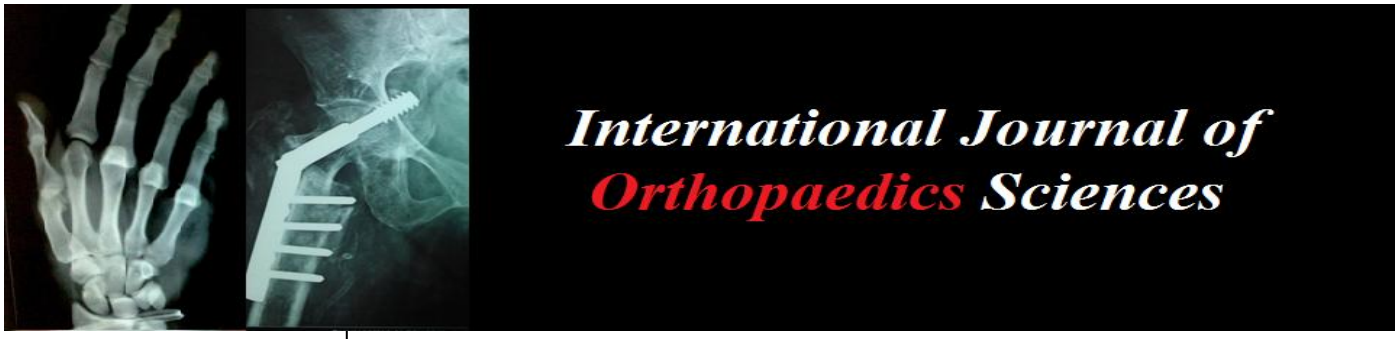

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Calcaneal bone density as a screening tool for osteoporosis

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Abstract
Introduction: Osteoporosis is a common disease in elderly associated with high morbidity and economic burden. Low bone mass is the strongest predictor of low and moderate energy fracture risk. As there are accurate as well as safe diagnostic tests available and treatment is effective, early diagnosis and quantification of bone loss and fracture risk have become more important so that it can slow or even reverse the progression of osteoporosis.
Material and Methods: This is a prospective study, conducted on patients with intertrochantric and neck of femur fractures in the age group of 50 to 75 years. The period of study is 6 months from May 2017 to October 2017. 96 Patients (34 neck of femur and 62 intertrochantric fractures) were selected into the study from those presenting to Victoria hospital and Bowring hospital, Bangalore medical college and research institute, Bangalore. The calcaneal X ray of the uninjured limb was taken along with the X ray of pelvis with both hip joint. The films were then scored based on the trabecular pattern by 2 different observers and recorded in separate charts. After a minimum of 2 weeks, the same observers scored the radiographs again for assessment of intra-observer reproducibility. Calcaneal index score and Singhs index scores were compared.
Results: As the age progressed there is a linear relationship in the bone density and the calcaneal index scored. However there is some discrepancy in the score of Singhs index and Calcaneal index. But this difference is not a statistically significant.
Conclusion: Calcaneal index can be used as a screening tool for diagnosing osteoporosis, it is cost effective, requires less radiation dose exposure and the radiation directed away from the gonads, even though it does not predict the exact bone density.

Keywords: Osteoporosis, calcaneal index, Bone mineral density

Introduction
Reduced bone density is a common radiological finding in elderly, postoperative patients and patients immobilized secondary to trauma. Significance of osteoporosis has led to research to find if simple radiographs can be helpful in assessing osteoporosis. The primary health care provider can play a significant role in identifying patients at risk of developing the complications of weak bones.
Osteoporosis is a common disease associated with high morbidity and economic burden. As there are accurate and safe diagnostic tests available and treatment is effective [1, 2]. Early diagnosis and quantification of bone loss and fracture risk have become more important so that it can slow or even reverse the progression of osteoporosis. Low bone mass is the strongest predictor of low and moderate energy fracture risk [3].
Bone density measurements (BMD) is common method for osteoporosis screening; though, the bone densitometers used for spine and hip measurements are expensive and requires skilled personnel, for therapeutic decision-making these measurements are indicated. Therefore, for screening osteoporosis a device that is small, less expensive, and easy to use.
The gold standard method recommended by the World Health Organization in the diagnosis of osteoporosis is dual-X-ray absorptiometry (DXA). Using this method, osteoporosis is defined by a bone mineral density (BMD) lower than -2.5 standard deviations (SD) of the reference BMD of Caucasian women aged 20-29 years [4].
There are various techniques for non-invasive assessment of skeletal status. These include conventional radiography, radiogrammetry, spinal and peripheral quantitative computed

tomography (QCT/PQCT), quantitative ultrasound (QUS), radiographic absorptiometry, single X-ray absorptiometry (SXA) and dual X-ray absorptiometry (DXA), and magnetic resonance imaging (MRI). The role of these techniques in the management of osteoporosis has been reviewed [5, 6]. Bone calcium content has to be reduced by approximately 30% before bone loss can be detected by plain radiography [7].

Materials and methods

This is a prospective study, conducted on patients with intertrochantric and neck of femur fractures in the age group of 50 to 75 years. The period of study was 6 months from May 2017 to October 2017. 96 Patients (34 neck of femur and 62 intertrochantric fractures) were selected into the study from those presenting to Victoria hospital and Bowring hospital, Bangalore medical college and research institute, Bangalore. The data collected with informed consent for the study from patient and their relatives by interview and their daily activities as pre injury state is also analysed to rule out any pathological fractures. The calcaneal X ray of the uninjured limb is taken along with the X ray of pelvis with both hip joint. The uninjured limb is considered as the positioning the for the lateral view will not be painful.

Patients who fulfilled the inclusion criteria were included in the study. Inclusion criteria were 1. All intra capsular and extra capsular fractures were considered, 2. Age of the patient > 50 years. Exclusion criteria were 1. Age of the patient < 50 yrs, 2. Pathological fractures, 3. Patients with associated injuries in the other lower limb.

The lateral radiographs of the calcaneum and the proximal normal femur for assessing trabecular pattern were obtained on a 75 kV high definition film screen, with a 0.6 mm focus at 115 cm anode to film distance. The films are coded and arranged in a random order for each reading. To study the inter- and intra-observer reliability, 2 observers are recruited. Observer A is an experienced orthopaedic surgeon and observer B is a fresh orthopaedic surgeon.

The films are placed on a conventional view box and compared. The films are then scored by 2 different observers and recorded in separate charts. After a minimum of 2 weeks, the same observers scored the radiographs again for assessment of intra-observer reproducibility. The observers are blinded to their scoring of the initial assessment. In a sagittal longitudinal section, the trabeculae are arranged in 2 groups corresponding to compressile and tensile stresses. The compressile trabeculae are disposed in 2 sets. The primary compressile trabeculae originated at the subtalar articular surface and diverged downwards and backwards through the waist of the calcaneum; the trabeculae became finer and more numerous as they passed backwards to fan out over the entire posterior surface. The secondary compressile trabeculae passed anteriorly from the subtalar articular surface to the articulation with the cuboid. The primary tensile trabeculae arose from the inferior surface of the calcaneum and ran backwards and upwards to reach its posterior surface. The thinner and widely spaced secondary tensile trabeculae ran anteriorly towards the cuboidal surface and intersected the secondary compressile group.

Based on these the bone density is classified into 5 grades, grade V and IV are normal density, grade III is borderline, grade II is osteoporotic and grade I is severely osteoporortic.[8]

Grade V: The compressile and tensile trabeculae are uniformly distributed.

Grade IV: The primary compressile trabeculae are divided into 2 pillars separated by a radiolucent caused by recession and disappearance of the middle portion of these trabeculae.

Grade III: There is also recession and disappearance of the primary tensile trabeculae which cross only the pillar of the primary compressile trabeculae.

Grade II: The secondary tensile trabeculae have disappeared and the primary tensile trabeculae have receded.

Grade I: There is complete disappearance of both sets of tensile trabeculae; the compressile trabeculae are reduced in number and are thin.

Results

We studied total 96 cases, 65 female and 31 male patients. The age group has been sub divided into 5 groups. The majority of the cases are in the age group of 60-70 years. Singh's index and calcaneal index of same patient is calculated and scored. As the age progressed there is a linear relationship in the bone density and the calcaneal index scored. However there is some discrepancy in the score of Singhs index [9] and Calcaneal index [8]. But this difference is not a statistically significant.

Distribution of cases

Fracture type		Male	Female
Inter trochanteric	Right	13	26
	Left	7	16
Neck of femur	Right	5	12
	Left	6	11

Singh's index and calcaneal index

Age group (years)	No of cases	Avg Singh's index	Avg Calcaneal index
51-55	16	3.6	3.0
56-60	25	3.1	2.5
61-65	28	2.8	2.3
66-70	19	2.2	2.3
71-75	8	2.1	2.0

Grade 2

Grade 3

Grade 4

Grade 5

Discussion: The relationship between risk factors for osteoporosis and bone mass has been extensively investigated in several epidemiologic and observational studies [10, 11]. The common risk factors for osteoporosis are prior fragility fracture, age, family history low body weight, sedentary lifestyle, early menopause, smoking, high caffeine intake, and low calcium intake [12, 13].

BMD in the assessment of risk has high specificity but low sensitivity, indicating that many fractures will still occur in individuals considered to be at low risk [1]. This is one of the reasons why BMD alone cannot be used for population screening. The use of independent risk factors in addition to BMD improves the sensitivity without a loss of specificity. The maximum density, being the area with the greatest concentration of trabeculae because of the presence of the calcaneal thalamic trabecular system, the calcaneal anterior apophyseal trabecular or sinus system and the sustentaculum tali trabecular radiations [14]. Followed by the posterior region, having its own calcaneal trabecular system, the trabecular system of the heel corresponding to the insertion of the Achilles tendon [15].

Osteoporosis can be assessed from the radiographs, but bone mineral mass cannot be estimated [16]. There are several articles suggesting correlation between the degree of osteoporosis and bony architecture [17]. The grading of trabecular pattern in the calcaneum also correlates with that of the hip.

In a similar study by Dr Jhamaria *et al* [7], they found a linear relationship between the calcaneal index and Singhs index and the calcaneal index values of our study and their study are comparable.

The calcaneal index is based on the same morphological assumptions as the Singhs index, and few debate that the calcaneal index can be a more sensitive indicator as the heel carry the whole body weight and the Os calcis is known to be related to weight [18]. However the activity of the individual, bare foot walking and the footware worn influences the calcaneal cancellous bone structure.

Even though the prevalence of the osteoporosis is high, it is less diagnosed and treated as the patients are asymptomatic. By screening the elderly for osteoporosis many cases of fragility fractures can be prevented.

Conclusion

Calcaneal index can be used as a screening tool for osteoporosis, it is cost effective, requires less radiation dose exposure and the radiation directed away from the gonads, even though it does not predict the exact bone density.

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