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Utility of Singh index as screening test for osteoporosis

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Abstract:

Osteoporosis is a very common skeletal disease. Various methods have been devised for quantitative assessment of the bone mass in osteoporosis. DEXA scan is the gold standard for measurement of bone mineral density at present but use of DEXA for mass screening of osteoporosis in low and middle income population may not be feasible as it is expensive and not easily accessible.

The present study was conducted to determine the utility of Singh Index as diagnostic tool in osteoporosis. This was a prospective study. 154 female postmenopausal female subjects were enrolled in the study. The trabecular pattern of upper end of femur was studied and graded according to Singh Index and quantitative assessment of BMD was done by the ultrasound bone densitometry. The mean age was 52.07 years (40 – 80 years). The mean duration since menopause was 10.19 years (1-35 years). More number of subjects (120) were detected normal by Ultrasound BMD then by Trabecular pattern (67 subjects); 30 were detected osteopenic (borderline) by BMD whereas 53 by Trabecular pattern. A significant positive correlation between trabecular pattern and BMD i.e. as trabecular loss increases BMD decreases.i.e. loss of trabeculae signifies decrease in bone mineral density.

We conclude that postmenopausal osteoporosis is quite a big problem in India. As prevention by timely detection and early prophylactic nutritional supplementation is the only effective treatment strategy, cost effective and easily accessible tests should be devised to screen population for osteoporosis. If evaluated carefully Singh's index can be a useful tool in screening osteoporotic patients, as it is relatively inexpensive and easily accessible.

Key words: Bone mineral density; Osteoporosis; Screening; Singh index; Ultrasound bone densitometry.

Introduction

Osteoporosis is a very common skeletal disease, characterized by low bone mass and microarchitectural deterioration of bone tissue, leading to enhanced bone fragility and a consequent increase in fracture risk. There is an absolute decrease in the amount of bone to a level below that required for mechanical support of normal activity [1].

Various factors are important when considering bone density and osteoporosis. They are mechanical stress, the level of calcium and phosphate ions in the extracellular fluid, effects of hormones (Calcitonin, Parathormone, sex hormones etc.) on bone remodelling. Sex hormones probably regulate the frequency of new remodelling cycles and also may adjust the balance of resorption and formation within each cycle. Estrogen deficiency results in unbalanced osteoclast and osteoblast activity such that more bone is removed than is formed. A decline in sex hormones causes breakdown of the link between resorption and formation and the architectural integrity of the bone is affected leading to increase in risk of fracture. Bone density declines at the rate of 1-5% at the beginning of menopause when estrogen deficiency surfaces. During the first six to eight years of menopause, there is a sharp decline in bone mineral density.

Various methods have been devised for quantitative assessment of the bone mass in osteoporosis. Bone mass can be measured by Bone Mineral Densitometry (BMD) techniques using various methods -

Ultrasonography(USG)
Single Photon Absorptiometry (SPA)
Dual Photon Absorptiometry (DPA)
Single energy X-Ray absorptiometry (SEXA)
Dual energy X-Ray absorptiometry (DEXA)
Quantitative Computed Tomography (QCT)

DEXA scan is the gold standard for measurement of bone mineral density at present but use of DEXA for mass screening of osteoporosis in low and middle income population may not be feasible as it is expensive and not easily accessible. Hence the relatively cheap and easily available methods to assess bone mass should be utilised.

Bone mass has been measured in the past by studying trabecular patterns at upper end of femur, calcaneus, and vertebral column. Patterns of trabeculae loss correlates with increasing severity of osteoporosis. These trabecular trajectories run in curved arches. Within these arches, individual trabecular are arranged in the direction of both compression and tension forces.

The trabeculae in the upper end of femur have been studied extensively in literature[2-5].

Four major anatomic groups of trabeculae have been described in upper end of femur:-

1. Principal compressive group
2. Secondary compressive group
3. Principal tensile group
4. Secondary tensile group

Ward's triangle: contains thin and loosely arranged trabeculae. This area is enclosed by trabeculae from the principal compressive, secondary compressive and principal tensile groups. It lies within the neutral axis, wherein compressive and tensile forces balance each other.

Singh et al [6] devised their index of osteopenia grading after showing a good correlation between histological osteopenia grading of iliac crest biopsies and trabecular pattern grading of contralateral hip roentgenograms. With increased degree of trabecular resorption, tensile trabeculae reduce in number and with a further increase in trabecular resorption the outer portion of the principal tensile trabeculae disappear. As the osteoporosis increases in severity, all trabecular groups are resorbed, with the exception of bony trabeculae in the principal compressive group. Ward's triangle gradually becomes translucent with increasing age.

Singh et al described six different trabecular resorption patterns, which represent increasing degree of bones loss. They are as follows: -

1. Grade six: All the normal groups of trabeculae are visible. The compressive and tensile trabeculae cross each other and the upper end of femur is completely occupied by cancellous tissue. Wards triangle is not clearly delineated. Graded as normal.
2. Grade five: There is an apparent accentuation of the structure of principal compressive and principal tensile trabecular groups. The secondary compressive trabeculae are no longer clearly demarcated. Ward's triangle appears empty and more prominent. Graded as early stage of bone loss.
3. Grade Four: The tensile trabeculae are markedly reduced in number. The principal tensile trabeculae in the outer portion of the bone can be traced in continuity from the lateral cortex to the upper part of the neck of the femur. The secondary compressive trabculae are completely resorbed hence Ward's triangle opens up laterally. It represents borderline between osteoporotic and normal skeletons.
4. Grade Three: This represents a break in the continuity of the principal tensile group of trabeculae opposite the greater trochanter. The tensile trabeculae are clearly seen only in the upper part of

the femoral neck, where they are still comparable in density to the principal compressive trabeculae. This pattern indicates Definite Osteoporosis.

5. Grade two: The only prominent trabeculae are the principal compressive group. All other group's are almost completely resorbed and have become roentgerographically inconspicuous. This is an index of a moderately advanced osteoporosis.

6. Grade one:- The principal compressive trabeculae are markedly reduced in number. There is very little difference in the density of the soft tissue and the porotic bone.

The present study was conducted with the following objectives-

1. Study of trabecular pattern of upper end of femur radiographically using Singh Index to evaluate usefulness of Singh index in screening.
2. Comparison of BMD and trabecular pattern to evaluate the degree of osteoporosis.
3. To determine any correlation between the degree of osteoporosis and years since menopause.

Material & Methods

This was a prospective study. 154 postmenopausal healthy women, who had no evidence of disorders of liver, thyroid and parathyroid, malignancy and local bone pathology, were enrolled in the study. Subjects on chronic medication like corticosteroids, anticonvulsants, prolonged alcohol and drug abuse and prolonged immobilization were excluded from the study.

After informed consent, a detail history was taken and if the patient was fit to be included in the study, she was subjected to anthropometric measurements, Pelvic X-Rays, blood investigations and Ultrasound BMD measurements.

Antero-posterior radiographs of the pelvis were taken with both hips in 15o internal rotation. All the recorded radiographs were digitalized using an AGFA digitalizer. With constant resolution of image size 300 x 350 the proximal part of femur bone was cropped from the digitalized pelvis images.

The roentgenograms were then analysed on the basis of the presence or absence and the relative number and density of the trabeculae in the various trabecular groups and graded according to Singh's Index by a single senior radiologist.

Bone mineral density was measured by quantitative ultrasound (QUS) using the right calcaneus as the indicator for the present study. Evaluation of BMD was done by T-score.

Anthropometric Measurements

Height was determined using a wall mounted Stadiometer.

Body weight was determined using balance scale. Subjects were weighed without shoes.

Body mass Index (BMI) was calculated from measured weight (kg) and height (m).

Blood collection and Biochemistry

Venous blood was collected from all subjects and samples sent to central laboratory for following test.

Serum calcium,
Serum phosphorus,
Serum alkaline phosphatase,
Random blood sugar
Haemoglobin

Results

Total 154 subjects were enrooled in the study. The mean age was 52.07 years (40 – 80 years). The mean duration since menopause was 10.19 years (1-35 years)

More number of subjects (120) were detected normal by Ultrasound BMD then by Trabecular pattern (67 subjects); 30 were detected osteopenic (borderline) by BMD whereas 53 by Trabecular pattern.

Only four patients were found osteoporotic by ultrasound BMD while 34 were diagnosed with osteoporosis according to Singh's scale but there was no subject with Singh's grade II or I. Maximum number of Osteopenic subjects were in 45-55 years age group. Sharp and steady decline in Trabecular grading in 45-50-year age group, a gradual fall in 50-55 year age group and then 60-65 year age group. Sharp decline in BMD values in 45-50 year age group. Relatively less decline in 50-55 years and almost static after 65 years of age. No effect of serum calcium on trabecular grading and bone mineral density. Rapid loss of trabeculae in first five to ten years of menopause and then a gradual fall thereafter. Rapid decline of BMD in first 5-10 years after menopause and then a gradual fall as years since menopause increase.

A significant positive correlation between trabecular pattern and BMD i.e. as trabecular loss increases BMD decreases.i.e. loss of trabeculae signifies decrease in bone mineral density.

Discussion

The Singh index [6] is a diagnostic classification and is widely used method for estimating the degree of osteoporosis in daily clinical practice and research. We have tried to establish its accuracy by comparing it with quantitative Bone mineral density. The roentgenograms show an intermediate stage in the transition from one grade to the next and may sometimes be difficult to grade.

This leads to occasional differences of opinion, which, however, do not amount to more than one grade.

In our study of 154 post menopausal women (40-80 years), we have found significant positive correlation between the Trabecular loss and degree of osteoporosis as reported and graded by Singh et al. Cooper et al [7] reported a good correlation between bone ash density and trabecular pattern in excised femoral heads, concluding that the Index may be useful in measurement of bone mass in the proximal femur. Hubsch et al [8] using DEXA measurement taken in the femoral neck for BMD, found good correlation with trabecular pattern in his study.

Our data show that the Singh index method of grading osteopenia has a low sensitivity but a relatively high specificity as is also reported by Singh et al [6].

Our study shows significant correlation between years since menopause and loss of trabeculae of proximal end of femur. It was observed that there is a sharp decline of trabeculae in 45-55 year age group and second sharp decline in trabecular pattern after 65 years of age. Same observation was seen with decrease in bone mineral density.

Khairi et al [9] in a comparative study of trabecular pattern with bone mineral content measured by I125 photon absorptiometry at mid shaft radius found that bone mineral content was significantly lower in patients with Singh grade IV when compared with Singh grades V and VI. Masud et al [10] showed a moderate correlation between trabeculae and BMD measured at femoral neck by DEXA in a study of 659 post-menopausal women. Lips et al [11] compared the ability of radiological measurements such as Singh Index, vertebral fracture index, and metacarpal cortical thickness to predict the risk of hip fractures and found the trabecular pattern to be the most useful indicator. Gluer et al [12] found radiographic measurements of trabeculae, trochanteric region width, femoral neck and femoral shaft cortical thickness capable of predicting hip fractures as comparable to measuring femoral neck BMD using DEXA.

Wilkinson et al [13] found a significant correlation between the trabecular pattern and the force required to fracture the femoral neck. Koot et a [14] and Goel et al [15] showed a positive correlation concluding femoral BMDs significantly lower with decreasing trabecular grading.

Kranendonk et al [2] studied relationship between trabecular pattern of proximal femur and measured BMD using radius (mid shaft) by I125 photon absorptiometry method and concluded that there was no significant correlation between trabecular pattern of proximal femur and bone mineral content of the radial shaft.

Wicks et al [16] found trabecular pattern to be an unreliable predictor of bone content in their study on femoral heads. Pogrund et al [17] found the trabecular pattern less useful. They could not find any correlation between the trabecular grading with incidence of hip fracture and found the trabeculae of proximal femur to be a less sensitive indicator of spinal osteoporosis than semi quantitative assessment of spinal roentgenograms.

Sartoris et al [18] found no significant correlation between the trabecular pattern and BMD measurement by Dual energy scanned projection radiography.

Conclusion

We conclude that postmenopausal osteoporosis is quite a big problem in India. As prevention by timely detection and early prophylactic nutritional supplementation is the only effective treatment strategy, cost effective and easily accessible tests should be devised to screen population for osteoporosis.

We also stress upon early diagnosis and treatment as we found in our study a sharp decline in BMD in early postmenopausal period.

If evaluated carefully Singh's index can be a useful tool in screening osteoporotic patients, as it is relatively inexpensive and easily accessible.

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