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ORIGINAL STUDY

Bone mineral density in young Indian adults with traumatic proximal femoral fractures A case control study

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There is scarcity of data on osteoporosis in India for the age group of 20-40 years when peak bone mass is achieved. This study aimed to assess bone mineral density (BMD) in patients in this age group with traumatic proximal femoral fractures, and to compare it with age matched controls.

Thirty patients aged 20 to 40 years with traumatic proximal femoral fractures and 30 healthy volunteers within the same age group were included in the study. Radiographs of the pelvis were taken to determine the Singh index, and DEXA scan of the unaffected hip was done to assess BMD. Fracture cases were compared with controls for significant difference in BMD. The male to female ratio of the study was 2:1. Based on Singh's index, 60% of fracture cases and 20% of controls were osteoporotic. T scores by DEXA revealed that 24 patients with fracture and 22 controls had osteopenia or osteoporosis. There was a significant difference in the Singh index between the two groups and no significant difference in BMD assessed by DEXA scan. No agreement was found between BMD determined by DEXA and Singh's index.

The study points that our population fails to attain an adequate peak bone mass. It also questions the applicability of Western data to Indian population. The findings also indicate that Singh's Index cannot substitute DEXA for diagnosis of osteoporosis.

Keywords: bone mineral density; DEXA; osteoporosis in India; Singh's Index.

INTRODUCTION

As the life expectancy is increasing, osteoporosis has assumed an enormous proportion and has become a major health problem worldwide (*11*). Epidemiological studies in India indicate that the prevalence of low bone density is amongst the highest in the world (*8*). Osteoporotic fractures tend to occur relatively early (10-20 years earlier) in Indian population than in their western counterparts, and they are more common in men (*21*).

There is scarcity of data quantifying the problem in India, especially in the age group of 20-40 years, when the population is supposed to achieve its peak bone mass. The present study aimed to assess Bone

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Mineral Density (BMD) in patients in the 20-40 years age group with traumatic proximal femoral fractures and to compare it with age matched controls.

The utility of Singh's index as a substitute to Dual energy X-ray absorptiometry (DEXA) for BMD measurement was also assessed.

MATERIALS AND METHODS

The study was conducted in a tertiary care hospital in Delhi, India between April 2006 and March 2007. Thirty patients in the age group 20-40 years with traumatic proximal femoral fractures incurred less than one week previously were included in the study. Thirty healthy volunteers in the same age group served as controls.

Patients with disorders known to influence bone mineral density were excluded. Commonly excluded disorders included thyroid and parathyroid diseases, malignancy, liver disorders, local bone pathologies, patients on chronic medication such as corticosteroids, anticonvulsants, prolonged alcohol and drug abuse and prolonged immobilisation.

After informed consent, the selected individuals had antero-posterior radiographs of the pelvis taken with both hips in 15^0 internal rotation to determine Singh's index *(22)*. An independent radiologist assessed all the radiographs for estimation of Singh's index. Subsequently, DEXA scan of the unaffected hip was done to assess BMD. Image magnification and internal rotation of the hip was kept constant for all cases and controls.

While measuring BMD with DEXA of the hip region, individual T scores of Ward's triangle in the neck of the femur, trochanter and shaft were assessed and their mean value was considered as T-score of the hip. T scores between 0 to –1 were considered normal, -1 to –2.5 as osteopenic and less than –2.5 as osteoporotic *(10)*. All DEXA scans were done on a single machine (GE Medical Systems DPX-NT, reference white Caucasian females). The screening of patients was performed within three days of presentation. There was no delay in treatment of the patients during the course of the study due to ongoing investigations.

Statistical analysis

Comparison between fracture cases and controls was based on Student's t-test or X^2 test as appropriate. Bland and Altman method of agreement was used to examine the relationship between BMD and Singh's index in both fracture cases and controls. To facilitate measurement of agreement, grade IV of Singh's index (Singh) was taken to represent the osteopenic group as in BMD assessed by DEXA scan. Singh's index was classified as normal (grades VI and V), osteopenic (grade IV) and osteoporotic (grades III, II and I).

RESULTS

There were 18 fracture cases in the 21-30 years age group and 12 in the 31-40 years age group. There were 15 volunteers in each age-matched control group. The mean age of patients with fracture was 30 years.

The male to female ratio of the study was 2:1. Of 30 fracture cases, 24 (80%) were males and 6 were females (M:F: 4:1). Amongst controls, 16 (53.3%) were males and 14 (46.7%) were females (M:F: 1.14:1).

Fifteen patients had intertrochanteric fractures, 10 had fractures of the neck of the femur and 5 had subtrochanteric fractures. Twenty-eight (93.3%) of 30 patients sustained the injury due to significant trauma while two patients had a trivial fall.

Singh's index in fracture cases and controls is depicted in table I. In fracture cases, 18 (60%) patients were osteoporotic (Grade I, II, III), 7 (23.3%) were osteopenic (Grade IV) and 5 (16.7%) were normal (Grade V, VI). These percentages were 20%, 46.7% and 33.3% respectively in controls.

Bone mineral density assessed using DEXA scan T-values from the unaffected hip revealed that 24 fracture cases and 22 controls had low bone mass (osteopenia or osteoporosis) (table II). Five of the 6 females in fracture cases and all females in the control group had low bone mass. The mean T score

Table I. — Singh's index in patients with fractures and controls

Grades	Patients with fractures	Controls
VI (normal)	0	0
V (normal)	5	10
IV (osteopenic)	7	14
III (osteoporotic)	8	3
II (osteoporotic)	9	2
I (osteoporotic)	1	1

Table II. — Distribution of T scores in patients with fractures and controls

T SCORES	MALES		FEMALES		TOTAL	
	Patients with fracture (1)	**Controls (2)**	**Patients with fracture (3)**	**Controls (4)**	**Patients with fracture (1+3)**	**Controls (2+4)**
Normal (0 to –1)	**5**	8	**1**	0	**6 (20%)**	8 (26.7%)
Osteopenia (-1 to -2.5)	**13**	8	**1**	11	**14 (46.7%)**	19 (63.3%)
Osteoporosis (< -2.5)	**6**	0	**4**	3	**10 (33.3%)**	3 (10%)
Total	**24**	16	**6**	14	**30**	30

of fracture cases was –1.88 (range –0.3 to –3.2) and that of controls was –1.41 (range –0.3 to –3.1).

Statistical analysis

When fracture cases and controls were compared as per T scores by DEXA, there was no significant difference in BMD in the two groups ($p > 0.05$), but there was a significant difference in BMD of fracture cases and controls when the two groups were compared using Singh's index ($p < 0.05$).

No agreement was found between BMD (by DEXA) of the hip and Singh's index when it was assessed combining fracture cases and controls (measure of agreement, kappa –0.028) (fig 1).

DISCUSSION

It is now generally accepted that the main factor causing osteoporosis is low peak bone mass when reaching adult age. After the growth spurt, the bone density keeps on increasing gradually until about 30 years of age. It is during this time, that an additional 15% is added to the skeletal mass (*18*). A high peak bone mass in young adult life is thought to protect against fractures later in life, as obligatory loss ensues. The relationship between BMD and fracture risk is continuous and there is no fracture threshold (*18*). Fracture risk must be lowest when bone mineral density (BMD) is highest – some time between ages 20 and 40 in healthy individuals (*18*).

Plain radiographs have been used conventionally for assessment of bone density. These may be inexpensive and easily available but have a very low sensitivity, as around 30-40% of demineralisation must take place before changes appear on a plain radiograph (*20*). DEXA scan is the gold standard for measurement of bone mineral density for clinical use (*20*) and has been shown to have high short-term and long-term precision as well as low rate of error in reproducibility in measurement of BMD (*10*). It can detect osteoporosis at a relatively early stage. Use of DEXA for mass screening of osteoporosis in low and middle income countries may not be feasible as it is expensive and not easily accessible. Hence, the relatively cheap and easily available methods to assess bone mass such as Singh's Index, Calcaneal Index, Radial Index and Metacarpal Index are in common use but these are relatively insensitive and detect osteoporotic changes at a relatively later stage.

In our study, the age group that is slated to achieve peak bone mass was taken for evaluation to know whether our population achieves an adequate peak bone mass, and it was observed that most of our patients had low bone mass when assessed by DEXA scan or Singh's index.

There was a male preponderance among the presenting fracture cases, with females constituting only 20% of the cases. This could reflect higher mobility of male individuals (especially in India where most women are confined to households) and thus more susceptibility to trauma. It has been observed that Indian males have a higher incidence of proximal hip fractures as compared to Indian females. This is in sharp contrast to their western

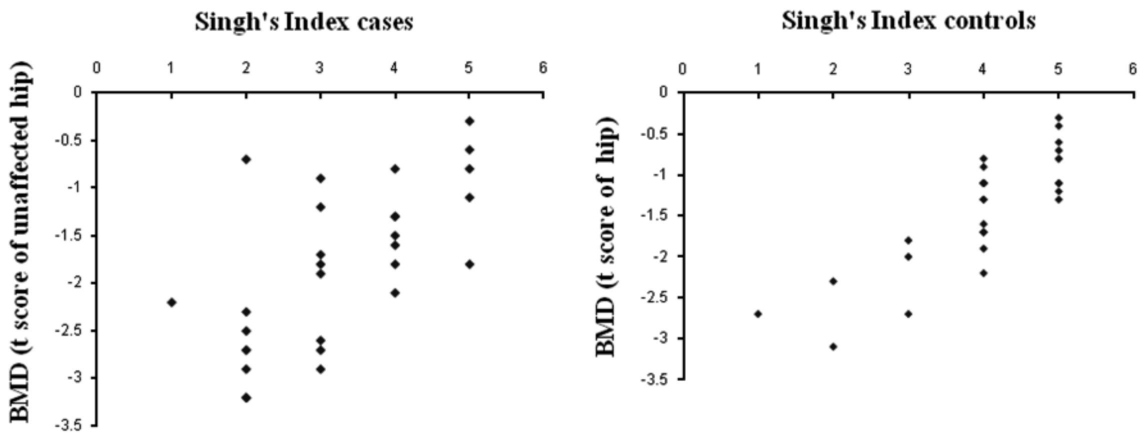

Fig. 1. — Figure 1 showing comparison of Singh's Index with T scores of the hip in fracture cases and controls

counterparts where females outnumber males in osteoporotic fractures, though majority of the studies involved older females (*3,6,8,23,26*). We did not determine the socio-economic and nutritional status of our patients, which could also be one of the reasons for this disparity.

Of the 6 females in fracture cases, 4 (66.7%) had osteopenia and 1 (16.7%) had osteoporosis as per BMD of the unaffected hip. Of the 14 females in the control group, 11 (78.5%) had osteopenia and 3 (21.4%) had osteoporosis. Ninety percent of females in our study had low bone mass. This reflects the gravity of the problem especially amongst Indian females. The percentage of males with low bone mass, on the other hand, was 79% in fracture cases and 50% in controls.

Distribution of patients according to mode of trauma revealed that 2 (6.6%) patients sustained fracture due to trivial trauma or falls and both of these subsequently turned out to be osteoporotic as per Singh's index and DEXA.

The prevalence of low bone mass (osteopenia and osteoporosis) in fracture cases as per DEXA was 80% while osteoporosis was detected in 33.4% of cases. A previous study evaluating osteoporosis in proximal femoral fractures in a similar region based on plain radiographs and iliac crest biopsy found that 33.5% of their 421 patients had osteoporosis but maximum number of their fractures occurred over 70 years of age where bone mass is already low due to obligatory losses (*24*). Only 10% of their patients sustained fracture when less than 50 years of age. Ahuja (*1*) measured the ash content and visual porosity of bones taken from 200 apparently healthy Indians who died in road accidents and found osteopenia in 12% of patients between 20 and 40 years of age (n = 84, 71% males and 29% females) and in 44% of males and females over the age of 50 years. In another study in South Asia, the screened patients (adolescent females) had a lower BMD as compared to their western counterparts and this was attributed to low dietary calcium intake and high prevalence of hypovitaminosis D (*12*). Western studies have primarily focussed on osteoporosis in the geriatric age group where osteoporotic fractures are far more common than in the age group under the present study.

DEXA scan findings revealed that more than 70% of controls in this study had a low bone mass and 10% had osteoporosis. This indicates a poor state of bone health in the population, particularly in the age group of 20-40 years when individuals are supposed to attain a peak bone mass. Since our population does not achieve an adequate peak bone mass, this deficiency probably compounds in later age when obligatory bone loss occurs, rendering them more susceptible to osteoporotic fractures. It is possible that a deficiency of calcium compounded by vitamin D deficit owing to inadequate and improper nutrition in the early years might be responsible for this low peak bone mass (*9*). In a study on South Asians who migrated to the United Kingdom (*19*), it was found that they had a low bone mass as compared to the native population owing to high prevalence of hypovitaminosis D, calcium deficiency and different dietary habits. This may be due to the tradition of covering their skin while going out, especially in women, leading to lesser sun exposure (*19*). Moreover, high content of phytates and phosphates in their diets may impair calcium absorption. Another suggested reason was the predominant vegetarian nature of the diet that these populations consumed, which often lacked adequate amount of proteins and calcium (*12,19*). Similar findings were reported by Walker *et al* in another population (*25*).

Therefore, the problem may not be confined to India or other South Asian countries, but any population that fails to attain peak bone mass owing to decreased dietary intake or absorption of calcium or high prevalence of hypovitaminosis D may have a low bone mass and potential risk of osteoporotic fractures.

The study may as well raise a question as to the validity of Western data while evaluating the Indian population. Racial, ethnic and socio-cultural factors also influence BMD of various communities. The DEXA machines used for studies in India and most countries are calibrated according to white Caucasian female data (*16,17*) and may falsely indicate higher prevalence of low bone mass in the screened population. Some single centre studies in this region have also consistently shown that BMD at all sites seems to be 5-15% lower in Indian women when compared to Caucasians (*2,5,16,17*). Hence, though the average healthy Indian may not have a low bone mass if compared to a native reference data (which is not available), the DEXA machines will label them osteopenic or osteoporotic as they are calibrated as per available Western data. This calls for large community based studies to assess the BMD of Indian population and set up appropriate reference data for evaluation of bone health of Indians. There has been an effort to obtain reference data for BMD for individual populations by mass screening in some countries (*25*) though the costs and machinery involved may limit such an evaluation in lesser developed countries.

The use of Singh's index in evaluating bone density has been controversial (*13-15*). It relies on observation and thus has an inherent drawback. The limitations of plain radiographs include inability to see the trabeculae clearly due to soft tissue shadow in a fatty patient with bulky thighs and buttocks and poor quality of radiographs due to technical lag. Digital radiographs of the pelvis with both hip joints may improve the precision to determine trabecular pattern and are highly recommended. We found no agreement between Singh's index and DEXA-BMD evaluation in our patients. Therefore measurement of BMD by Singh's index cannot substitute DEXA scan, which is the gold standard (*11*), for diagnosis and quantification of osteoporosis. Khairi *et al* determined that the evaluation of various trabeculae is highly subjective, especially for secondary compressive and tensile trabeculae (*13*). Griffth *et al* found that Singh's Index did not correlate well with cortical thickness or stress index (*7*). Koot *et al* also found no correlation between Singh's Index and DEXA (*14*). Thus Singh's index was labelled an unreliable measure of osteopenia. However, there have been studies demonstrating agood intraobserver and interobserver reproducibility in evaluation of Singh's index (*7,15*). Though Singh's index has a low sensitivity, it is highly specific in diagnosing low bone mass, indicating suitability for use in classifying large populations, but not individuals with osteoporosis (*7,15*).

The study has some drawbacks due to the relatively small sample size. The findings of the study (high prevalence of low bone mass) cannot be generalized for the whole Indian population though it indicates a possible public health issue. There may be inaccuracies in DEXA findings in shorter patients but we could not determine the height and weight characteristics of our patients (difficulty in measuring weight of fracture cases). It is difficult to comment on whether proximal femoral fractures in young adults are aetiologically associated with low bone density in the study, as the controls were healthy volunteers and were not subjected to the trauma that fracture cases underwent (high-energy trauma can fracture normal bones).

CONCLUSION

Peak bone mass is an important factor in determining the bone health. As the study points, our population may fail to attain an adequate peak bone mass. The small numbers were a limitation of our study, and a study of larger magnitude is required to ascertain the bone mass of our population. It also raises a question as to the validity of Western data i.e. BMD of white Caucasian population for comparison of populations which are racially, ethnically and socioeconomically different. It is suggested to produce an indigenous database spanning all age groups and both sexes to serve as a benchmark for comparison of Indian population.

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