TO EVALUATE THE UTILITY OF SINGH INDEX AS AN INDICATOR OF OSTEOPOROSIS AND A PREDICTOR OF FRACTURE NECK FEMUR

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ABSTRACT

Osteoporosis is the commonest metabolic bone disease in clinical practice and a major public health problem worldwide. The gold standard for the diagnosis of osteoporosis is Bone mineral density by DEXA. This investigation is expensive and not available in most Indian cities.

Aim of the present study was to assess the utility of Singh Index as an inexpensive tool for the screening of osteoporosis and also to predict the future risk of fracture neck femur in a high risk population. The study also aimed to grade the degree of osteoporosis according to Singh index in a population of patients with fracture and compare with age and sex matched controls. Methods: Thirty consecutive patients both males and females with fracture neck femur were compared with controls. Antero posterior X ray was obtained with hip 15 degrees internally rotated and Singh index(SI) was graded from 1 to 6. A lower SI represents a more osteoporotic bone. Results: The SI in the patient group was collectively significantly lower($p < 0.01$) than in the age and sex matched control group. This statistical difference persisted when females and males were matched as a group among patients and controls. The SI of 2 was the commonest in the patient group whereas that in the controls was 6 and none of the controls had a SI of less than 3. When SI scores were compared amongst controls and patients in various age groups there was a statistical difference ($p<0.05$) and the patients had a lower SI grade. Thus through this study we have been able to establish SI as an inexpensive tool for the diagnosis of osteoporosis in the high risk population and also as a possible predictor of future fracture in the population studied.

KEYWORDS: Osteoporosis, Fragility fracture, BMD (Bone mineral density), DEXA (Dual energy Xray absorptiometry), Singh Index (SI).

INTRODUCTION:

Osteoporosis, the commonest metabolic bone disease in clinical practice is a major public health problem worldwide and its prevalence is increasing with rise in the ageing population. It is a 'silent epidemic' with a significant burden of morbidity due to the fractures associated with the disease; common sites for which are the spine, hip and the wrist. In addition, fractures of hip are associated with 20 % excess mortality. The effective treatment strategies currently available for this disease mandate the early diagnosis and treatment much before the occurrence of complications of fracture.

The National Institute of Health (United States) consensus conference in the year 2000 has defined osteoporosis as a skeletal disorder characterized by compromised bone strength predisposing a person to an increased risk of fracture wherein bone strength reflects the integration of bone density and bone quality. (NIH consensus statements 2000)[1]

The clinically applicable index of bone quality is the history of a 'Fragility Fracture' provided by the patient. A fragility fracture has been defined by WHO (1998)[2] as "a fracture caused by injury that would be insufficient to fracture normal bone; the result of reduced compressive and or torsional strength of bone".

In India, osteoporosis is very rampant and medical facilities for its early diagnosis and treatment are still not widely prevalent and where available may not be within the financial means of a common man. Hence a more widely available and less expensive screening tool is conventional radiography used in conjunction with the Singh Index (Singh M et al 1970)[3].

Dual energy X-ray absorptiometry (DEXA) is presently the best method for measuring bone mass because of high accuracy and low precision error but it is expensive (Soontrapa S et al 2005)[4] and

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population based screening using DEXA cannot be justified in the Indian context. (Action plan osteoporosis consensus statement OSI ,2003)[5]

The technique using Singh Index based on trabecular patterns present in proximal femur as visible on X-ray hip has several advantages over the methods currently in use-

1) Anatomically the upper end of the femur is a choice site for the study of osteoporosis (Collins DH ,1966)[6]
2) The method is technically simple and requires an X-ray to delineate the internal architecture of the proximal end of the femur.
3) This method is universally applicable because the grading is based on bone structure rather than on bone quantity. The internal architecture of the upper end of the femur is independent of variables like age, sex and race (Trotter et al 1960)[7].
4) The trabecular pattern has been graded from 6 to 1 only as increasing amounts of the original bone are lost. Thus each individual acts as his / her own control.

These make it an ideal tool for mass surveys and routine diagnosis of osteoporosis.

Lips et al (1984)[8] compared the ability of radiologic measurements such as Singh index, vertebral fracture index and metacarpal cortical thickness to predict hip fractures. They found the Singh index to be the most useful of the three in separating 125 hip fracture patients from 74 elderly controls.

Patel and Murphy (2006)[9] conducted a study on 20 embalmed human bone specimens and proposed that the Singh index is a valuable and reliable indicator which may reflect structural integrity in trabecular bone. In this study they have also suggested the potential impact of prophylactic augmentation in populations at risk for femoral neck pathology.

AIMS AND OBJECTIVES:

The present study aims:

1) To grade the degree of osteoporosis according to Singh index in population of patients with fracture neck femur and compare it with age and sex matched controls.
2) To assess the utility of Singh index as an inexpensive screening method for osteoporosis and to predict the fracture risk of neck femur.

MATERIAL AND METHODS:

The study included 30 consecutive patients with fracture neck femur. The patients were taken from the Department of Orthopaedics, MY group of hospitals, Indore which is a teaching and the largest hospital in the state.

A detailed history was taken and examination was done to rule out causes of traumatic fractures and secondary osteoporosis (chronic liver disease, hyperthyroidism, hyperparathyroidism, multiple myeloma, rheumatoid arthritis, chronic renal failure). History of drug intake for gluco-corticoids, anticonvulsants, fall from standing height or minor trauma, past history of fracture, family history, menstrual and menopausal history in women was also taken besides history of calcium supplementation. The tests done on patients included serum phosphorus, serum calcium,serum alkaline phosphatase,serum albumin and serum creatinine.

Controls belonging to the same age and sex were selected as controls from MGM Medical College, Indore, hospital staff and Asthaa Old Age Home, Indore.

The patients and controls were divided into four age groups namely 45 to 54 yrs, 55 to 64 yrs, 65 to 74 yrs and 75 yrs and above.

Informed consent was taken from all patients and controls.

TECHNIQUE:

Anteroposterior X-rays of both hips were obtained with the hip internally rotated by 15 degrees. These X-rays were graded according to the criteria of Singh and associates (2005)[3].

In the neck of the femur,the principal compressive , the secondary compressive and tensile trabeculae enclose an area containing some thin and loosely arranged trabeculae and this is known as Wards triangle. In normal hip X rays all the trabecular groups are clearly demarcated but areas like Wards triangle where the trabeculae are thin and Roentgenographically inconspicuous appear empty. (Fig.1)

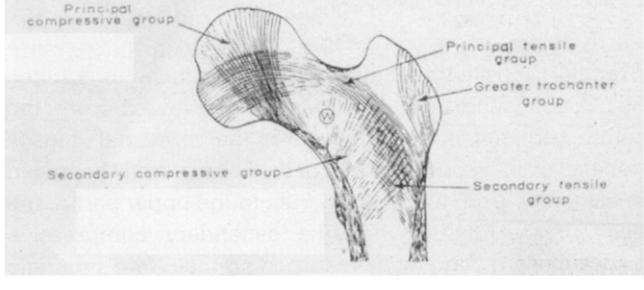

Fig. 1: Normal Trabecular Groups & Wards Triangle (W) according to criteria of Singh and associates

Six different trabecular patterns were studied and graded in order of increasing degrees of bone loss. (Fig. 2 through Fig. 7)

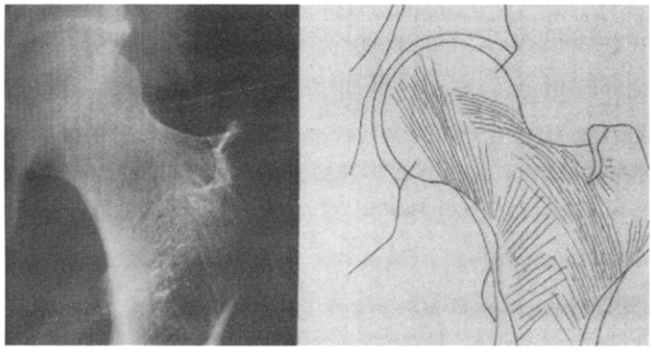

Fig. 2

Grade 6 : All the normal groups of trabeculae visible in X-ray. Ward's Triangle shows some thin trabeculae and is not clearly delineated.

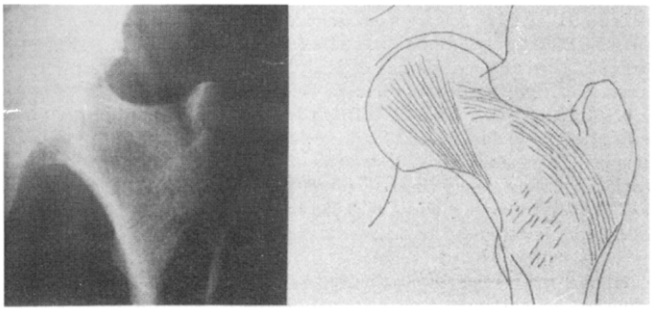

Fig. 3

Grade 5 : Apparent accentuation of principal compressive and principal tensile trabeculae due to the resorption of many thin trabeculae which were obscuring their structure. Secondary compressive trabeculae are no longer clearly demarcated. So Ward's triangle looks empty and more prominent. Represents early stages of bone loss.

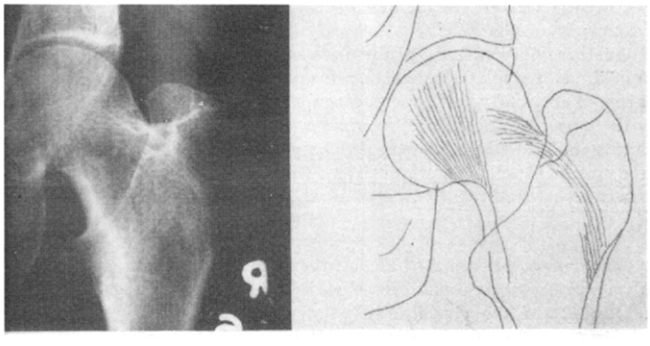

Fig.4

Grade 4 : Tensile trabeculae markedly reduced in number. Resorption seems to be proceeding outward from the centre of the bone. Therefore the principal tensile trabeculae in the outer portion of the bone can still be traced in continuity from the lateral cortex to the upper part of the neck of the femur while the secondary compressive trabeculae are completely resorbed so that Ward's triangle opens up laterally. This represents borderline between osteoporotic and normal skeleton.

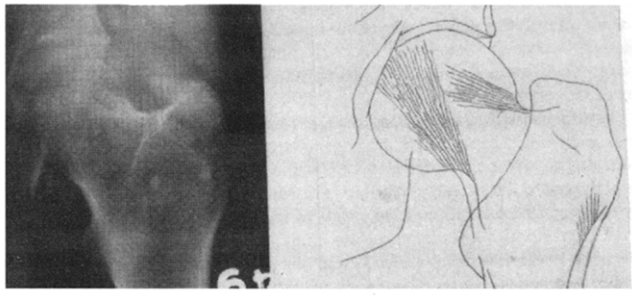

Fig. 5

Grade 3 : There is a break in the continuity of the principal tensile trabeculae opposite the greater trochanter. 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 represents definite osteoporosis.

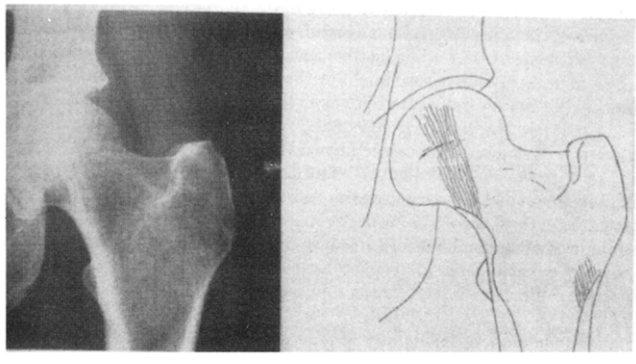

Fig. 6

Grade 2 : Only prominent trabeculae are the principal compressive group. All other groups are more or less completely resorbed and have become roentgenographically inconspicuous. This represents moderately advanced osteoporosis.

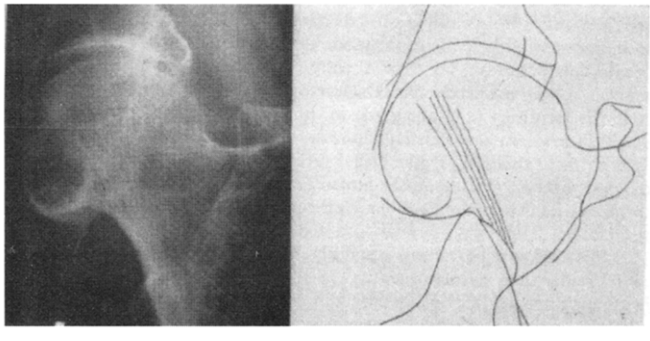

Fig. 7

Grade 1 : With still further bone loss even the principal compressive trabeculae do not stand out in X-rays and are markedly reduced in number.

It has been observed that the trabecular patterns are found to be symmetrical on the two sides.

	Mean Age (years)	Males/Females
Patient Group (n= 30)	64.26 (45 - 85 years)	12/18
Control Group (n = 33)	63.39 (45 - 84 years)	20/13

Table I : Base line characteristics of patients and controls

	Patient	Control	P value
All	2.9 ± 1.124	5.18± 0.82	P<0.01
Males	3 ± 0.953	5.53±0.611	P<0.01
Females	2.83 ± 1.25	4.77±0.93	P<0.01

Table II : Mean ± SD scores for SI in patients and controls

Age groups (years)	SI Scores (mean ±SD)		p value
	Patients(n=12)	Controls (n=20)	
45 - 54	3.2± 1.09	5.75± 0.5	P < 0.05
55 - 64	- *	5.5±0.547	-
65 - 74	2.33 ± 0.58	5.2±0.84	P < 0.05
> 75	3± 1	5.75 ±0.5	P < 0.05

Table: III: Age and sex matched (males vs males)
* Could not be calculated as only one male in patient group

Age groups (years)	SI Scores (mean±SD)		p value
	Patients (n=18)	Controls (n= 13)	
45 - 54	3.33± 0.58	5.67± 0.57	P < 0.05
55 - 64	3±1.55	4.0±0.82	NS
65 - 74	2.83 ± 1.47	4.75±0.95	NS
> 75	2± 0.0	5.00 ±0.00	-*

Table : IV: Age and sex matched (females vs females)
NS : Not Significant *SD=0.00

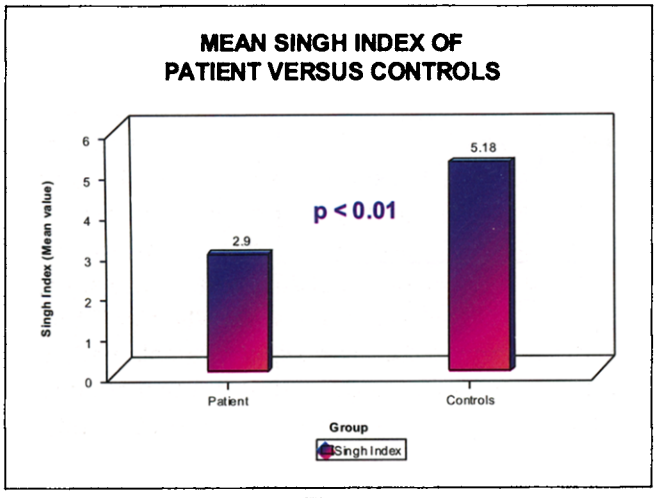

Fig. 8

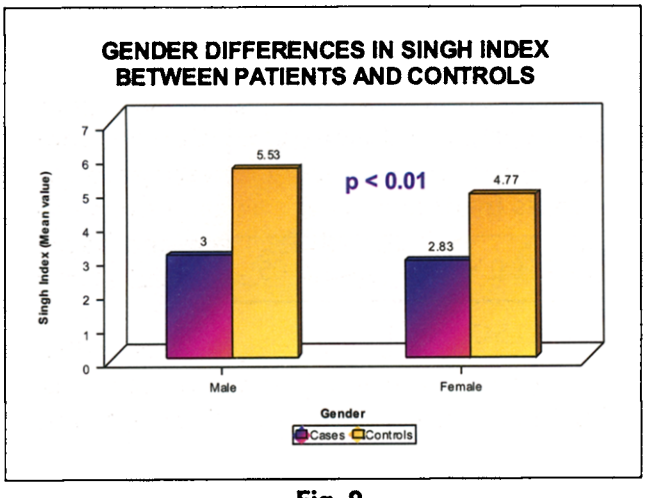

Fig. 9

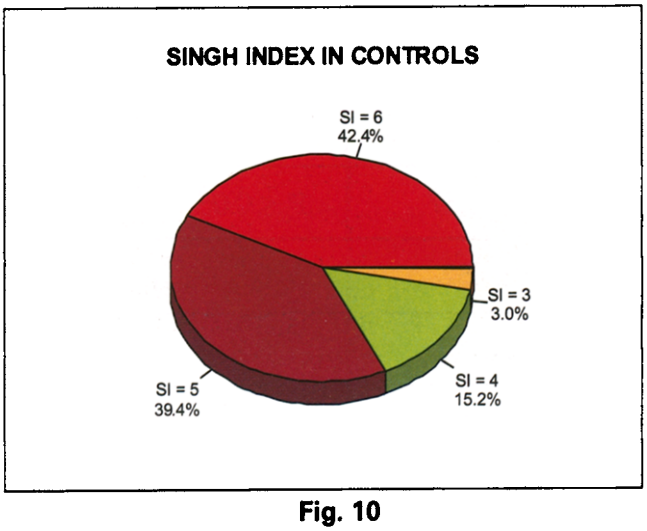

Fig. 10

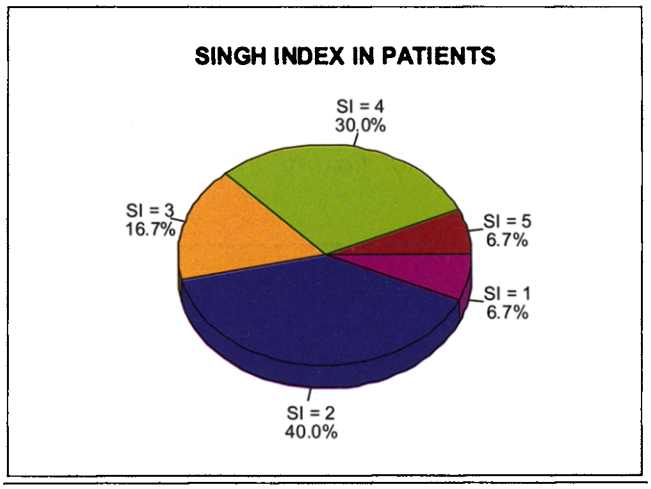

Fig. 11

STATISTICAL ANALYSIS:

Done using SPSS for windows. A z test (for independent sample means) and student t test was applied for comparing the Singh Index (SI) scores between the patient group and the control group. A p value of < 0.05 was considered significant.

RESULTS:

Baseline characteristics samples are given in the Table I. The SI in the patient group collectively was significantly lower than in the control group and this was statistically highly significant. (Table II and Fig. 8)

When SI of males in the patient group was compared with the SI of males in the control group, the grading was found to be significantly lower in the patient group and this was statistically highly significant. (Table III)

Similarly when female SI scores were compared between patients and controls, the difference was statistically highly significant ($P < 0.01$) with the grades being lower in the patient group. (Table IV and Fig. 9)

When the patients and controls were matched for age and sex and their SI compared in the various age groups, the SI in male patients were found to be lower and the difference was statistically significant ($P < 0.05$). (Table III)

In the female population it was found significant only in the 45 to 54 year age group. (Table IV)

In order to see age related changes in SI, the SI grading of the lowest age group i.e. 45 54 years was compared with the age group of 75 yrs and above and the difference was found significant in females and not significant in males. The SI grading of 2 (n = 12; female : 7 and male : 5) was the commonest grade in the patient group. SI grades 2 and 4 were the most

common in the male population of the patient group while in females of the patient group, SI 2 was the commonest. The commonest SI in control group was grade 6. None of the individuals of the control group had a SI < 3 whereas there were 14 individuals with SI < 3 in the patient group. 2 women in the patient group had a non traumatic fracture in the past. One of them was 80 yrs old and had a SI of 2 while the other was 60 yrs old and had a SI of 4. (Fig. 10 & Fig. 11)

Of all the individuals in the patient and control group only 6 were on some form of calcium and vitamin D replacement (4 in the patient group and 2 in the control group)

3 women of the patient group had had a premature menopause (i.e. menopause < 40 yrs of age). Out of them one had a history of previous fragility fracture and had a SI of 3.

DISCUSSION

This study presents us with an inexpensive tool for the screening of osteoporosis. In the present study, we found significant differences in the SI of patients who had suffered fracture neck femur from controls like the original investigators.3 This leads us to believe that

1) Singh Index indeed represents bone quality and a fall in the grades predisposes to fractures.
2) It also to some extent helps us to predict, when used as a screening tool, future fractures of neck femur.

Certain guidelines for prophylactic hip augmentation and measures for fall prevention can be advised to aged with low SI. Diagnostic classifications are useful if they help decisions about treatment or if they have prognostic value. Patel SH and others] proposed that Singh Index is a reliable indicator for prophylactic hip augmentation in population at risk for femoral neck pathology. Lips et al8 compared the ability of radiological measurements such as Singh Index, vertebral fracture index and metacarpal cortical thickness to predict hip fractures. They found the Singh Index to be the most useful of the three methods in separating 125 hip fracture patients from 74 elderly controls.

Gluer et al[10] found radiographic measurements of Singh Index, trochanteric region width, femoral neck and femoral shaft cortex thickness capable of predicting hip fractures as powerfully as femoral neck BMD measured using DEXA.

This difference in SI grading persisted when males were matched for age in the patient and control groups suggesting that a less grade was responsible for the fracture. When female SI scores were compared separately in all age groups significant differences were found in the age groups of 45 to 54 years but not in the other age groups. Dequeker et al11separated individuals with hip fractures from age-matched controls in a group of 90 women. Why some age groups did not show a statistically significant difference in spite of the scores in the female patient group being low could be due to the fact that fracture depends on several factors like visual acuity, propensity to fall, low muscle mass etc.

Horsman et al[12] reported similarly good separation of fracture patients from controls in a study of 116 women.

The finding that Singh Index in controls and in patient group amongst age-matched males and females was similar, further endorses the fact that Singh Index is independent of gender variables[3].

The commonest Singh Index in the patient population was grade 2 and the second commonest being grade 4. So we propose that all individuals with SI of grade 4 and below should have specific measures of fall prevention or perhaps hip augmentation along with general measures of diet rich in calcium and vitamin D, exercise and cessation of smoking and alcohol intake.

A study from Andhra Medical College by Sastry NV et al[13] showed similar results and predicted fracture risk with Singh Index. In our study the fact that Singh Index was significantly less in patients than age and sex matched controls points towards certain non-skeletal risk factors such as propensity to fall and genetic predisposition which needs to be investigated further. The higher number of females in the patient group is consistent with the fact that fall rates are higher in women and male bones are structurally stronger than female bones. Also men usually achieve a higher peak bone mass than women.[5]

Thus in conclusion we have been able to prove the usefulness of Singh Index as an inexpensive screening tool for osteoporosis and perhaps even predict the risk of fracture neck femur in patients with Singh Index less than 4 and highest risk in patients with SI of 2 or below.

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