• *Technical note*

# Comparison of Singh index accuracy and dual energy X-ray absorptiometry bone mineral density measurement for evaluating osteoporosis

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*Background:* The Singh index is an inexpensive simple method to evaluate bone density, commonly used to assess osteoporosis is based on the radiological appearance of the trabecular bone structure of the proximal femur on a plain antero-posterior (AP) radiograph. The purpose of this study was to compare between Singh index and bone mineral density measurement using dual energy X-ray absorptiometry (DXA). *Materials and Methods:* Three orthopedists evaluated radiographs of 72 patients suspected with osteoporosis. The inter-observer agreements of the Singh index were obtained by using kappa statistics. The bone mineral density (BMD) of proximal femur was measured by DXA in all patients, and then the BMD results were compared with those of Singh index by using reference radiographic charts of the Singh index method. Dual-energy X-ray absorptiometry was used to measure bone mineral density. A Norland XR46 system was used for the investigations. *Results:* The inter-observer agreement kappa values were 0.01, 0.07 and 0.09 (mean value: 0.05) and the strength of the observer agreements was negligible. The obtained osteoporosis prevalence among the studied patients was 38.9%. *Conclusion:* The inter-observer variation was large, there was no any correlation between the Singh index and bone densitometry. So, the index cannot be used; for evaluating and osteoporosis diagnosis, because of its low reliability. **Iran. J. Radiat. Res., 2010; 8 (2): 123-128**

***Keywords:*** *Singh index, BMD, osteoporosis, DXA, bone density.*

## INTRODUCTION

Osteoporosis is an important health problem characterized by low bone mineral density (BMD) and a reduction in bone strength [(1)]. The definition of osteoporosis by the World Health Organization (WHO) is a BMD that is 2.5 standard deviation (SD) or more below the mean of a young, normal reference population [(2)].

Osteoporosis causes no symptoms until a fracture occurs. Osteoporosis or low BMD is estimated to occur in about 44 million American men and women, accounting for 55% of the population age 50 and over [(3)]. If not prevented or if left untreated, osteoporosis can progress painlessly until a bone breaks. These broken bones occur typically in the hip, spine and wrist. Hip and spine fractures may result in chronic pain, deformity, dejection, disability and death. About 50% of patients with hip fractures will never be able to walk without assistance and 25% will require long-term care [(4)]. The mortality rate, five years after a fracture of the hip or a clinical vertebral fracture, is about 20% greater than expected [(5)], with mortality rates higher for men than

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women [6]. The Surgeon General's "Report on Bone Health and Osteoporosis" [7] and the National Osteoporosis Foundation's (NOF) "Physician's Guide to Prevention and Treatment of Osteoporosis" [8] identify osteoporosis as a major public health concern, and emphasize the importance of using BMD testing as a clinical tool to diagnose patients at high risk of fracture before the first fracture occurs.

Bone mass measurement is the single best predictor of fracture risk [9-12]. Techniques used to assess the risk of fractures include: 1) clinical assessment of risk factors and 2) physical measurement of skeletal mass. Bone mass can be measured by some techniques for evaluating the femoral neck trabecular morphology, i.e. the Singh index, radiogrammetry, radiographic absorptiometry, quantitative computed tomography (QCT), quantitative ultrasonography (QUS), or by energy absorptiometry (e.g. dual energy X-ray absorptiometry (DXA) or single energy X-ray absorptiometry (SXA)). DXA is an accurate technique for measuring BMD [9, 13]. The equipment is widely available and has the capacity of multi-site measurements mainly of the spine, hip and forearm [14]. The Singh index, which describes trabecular patterns in the proximal femur, has been used as a predictor for hip fractures and as an indicator of osteopenia. Evidence suggests that its contribution to the assessment of hip fracture risk is in its description of the structural properties of the femur. This pattern of trabecular bone loss has been characterized by Singh *et al.* [15], who devised a scale from 1 to 6 to describe the degree of trabecular bone loss from the proximal femur (Singh index). Each grade of the index was characterized by particular degrees of bone loss from the various trabecular groups in the proximal femur. Singh suggested that the index could be used to separate patients with spinal osteoporosis from normal individuals, and that the index reflected the bone loss throughout the skeleton. Subsequent studies have shown that the Singh index usefulness in predicting skeletal bone mass has been overstated, and that the index is significantly inferior to photon absorptiometry methods [16-20].

The Singh index is an inexpensive simple method of assessing bone density at a site where fractures occur. The Singh index has been criticized for its low reliability due to the subjective nature of its ill-defined grading of [21, 22], and cut-off level [15, 20], for osteoporosis.

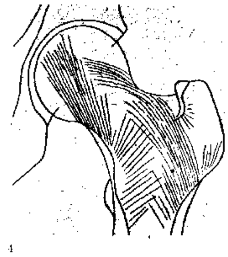
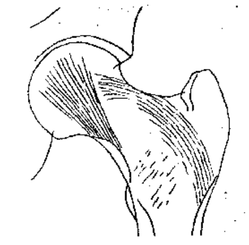
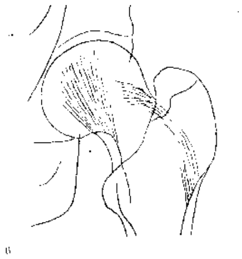
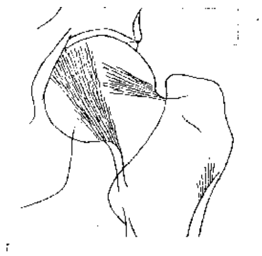
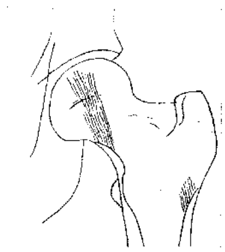
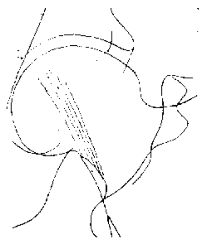
## MATERIALS AND METHODS

The study was carried out on referred patients to Esfahan Osteoporosis Diagnosis Center (IODC) and Azadeh Osteoporosis Diagnosis Center in Esfahan (Iran). For this purpose, 72 patients (68 women and 4 men) with a fracture of the femoral neck or trochanteric region were selected randomly. All referred patients filled a questioner about previous illnesses and drug use, gynecological history, nutritional habits, physical activity, education level, and other life-style habits.

To determine Singh index, the anterior-posterior (AP) hip joint radiographs were needed. Hip joint AP was performed with radiography conditions at kVp at 70 and mAs of 25. Six grades were assigned on radiographs by using reference radiographic charts of the Singh index method (table 1), and then were compared with DXA results. A Norland XR46 system was used for the investigations, which was programmed to measure and calculate the BMD of the femoral neck.

Patients with the following criteria were excluded from the study: 1) pregnant women, 2) disinclined patients for participating in the investigation, and 3) having orthopedic tools in body. After gathering and providing the radiographs in three separate sessions by three experienced orthopedists, the radiographs were analyzed and the Singh index was determined.

Table 1. Pattern of trabecular resorption in the femur due to osteoporosis [15].

| **Detail of Singh Index** | **Figure of Singh Index** |
|---|---|
| **Grade 6:** All the normal trabecular groups are visible and the upper end of the femur seems completely occupied by cancellous bone. |  |
| **Grade 5:** Principal tensile & principal compressive trabeculae is accentuated. Ward's triangle appears prominent. |  |
| **Grade 4:** Principal tensile trabeculae are markedly reduced in number but can still be traced from the lateral cortex to the upper part of the femoral neck |  |
| **Grade 3:** There is a break in the continuity of the principal tensile trabeculae opposite the greater trochanter, this grade indicates definite osteoporosis. |  |
| **Grade 2:** Only the principal compressive trabeculae stand out prominently, remaining trabeculae have been essentially absorbed. |  |
| **Grade 1:** Principal compressive trabeculae are markedly reduced in number and are no longer prominent. |  |

### Statistical analysis

For the determination of Singh index, reporting the densitometry results and analysis of other variables, Pearson and Spearman correlation coefficients (r), as well as $\chi^2$ tests were used. A P-value of <0.05 was considered as a significant level. The kappa statistic is a chance-corrected measure of agreement first described by Cohen [23]. Kappa values define the proportion of agreement in excess of that to be expected by chance alone. It compares an observed measure of agreement, with a level of agreement expected by chance alone. The maximum value of 1.0, means complete agreement and a value of zero indicates no agreement than expected by chance alone, and the value may be less than zero. Landis and Koch [24] criteria were used to assess the agreement level (table 2).

Table 2. Landis and Koch [24] criteria for kappa statistic.

| Kappa score | Level of agreement |
|---|---|
| 0.00–0.20 | Slight |
| 0.21–0.40 | Fair |
| 0.41–0.60 | Moderate |
| 0.61–0.80 | Substantial |
| 0.81–1.00 | Excellent |

Statistical analysis was performed with SPSS software. Correlations among the variables under study were established using Pearson and Spearman's coefficient of correlation, and differences among parameters were assessed using Student's *t-test*.

## RESULTS

The radiographs were observed by three different orthopedists. Each considered a Singh index for each radiograph. The agreements among the viewers were as bellow:
A) Between observer 1 and 2: Kappa = 0.01
B) Between observer 1 and 3: Kappa = 0.07
C) Between observer 2 and 3: Kappa = 0.09

As seen in table 2, observer agreements are negligible. The following results were obtained in this study:

1) Correlation and $X^2$ test between the Singh index and vertebral BMD response were calculated and then were seen, there was no significant correlation between them (r = -0.05).
2) The Singh index and hip BMD response were independent of each other and there was no significant correlation between them (r = 0.1 and p = 0.14).
3) There was no significant correlation between the Singh index and age (r = -0.1 and p = 0.26).
4) There was a significant negative correlation between hip BMD and age (r = -0.4 and p = 0).
5) There was a significant negative correlation between vertebral BMD and age (r = -0.3 and p = 0.001).
6) There was no significant correlation between the Singh index and the weight of patients (r = -0.02 and p = 0.93).
7) There was a direct correlation between vertebral BMD and weight (r = 0.3 and p = 0.001).
8) There was a direct correlation between hip BMD and weight (r = 0.4 and p = 0).
9) There was a significant negative correlation between the Singh index and height (r = -0.5 and p = 0.01).
10) There was no significant correlation between the Singh index and pregnancy number (r = 0.05 and p = 0.75).
11) There was a significant negative correlation between vertebral BMD and pregnancy number (r = -0.4 and p = 0.006).
12) The Singh index had high sensitivity in screening (96%).
13) Speciality of the Singh index in screening was poor (2%).
14) Positive prediction value of the Singh index was 38% and negative prediction value of it was 50%.

## DISCUSSION

In 1970, Singh *et al.* [15] demonstrated how the trabecular patterns of the proximal femur were disturbed in the course of osteoporosis. They, then, described six trabecular patterns: grade 6 representing a normal pattern, grade 4 osteopenia and grades 3 and lower increasing degrees of osteoporosis. The pattern of trabecular loss provided a semi quantitative estimate of osteoporosis, which would be a valuable tool in epidemiological studies.

Many investigations have been done so far indicate the Singh index is an appropriate method for the diagnosis of osteoporosis and screening, this index has even been mentioned in orthopedic reference books. In contrast, a large number of studies have exactly shown the opposite of mentioned investigations.

In the investigation, Koot *et al.* (22) studied the reliability of the Singh classification of trabecular bone structure was studied in the proximal femur as a measure of osteoporosis, using kappa statistics. On the basis of their findings they consider that the Singh index has no value in assessing the grade of osteoporosis (22).

In a study on 60 healthy women, which was done by Soontrapa *et al.* in 2005 in Thailand (25), it was shown that the Singh index has had poor reliability and poor diagnostic value in screening of femoral neck osteoporosis (25).

In this study, after we analysis the data, we found that there was no significant correlation between the Singh index and bone densitometry and we cannot use this index for the evaluation and diagnosis of osteoporosis.

There were two main deficiencies in this index:

1) Many patients, who had different BMDs, had similar Singh index.

2) There was no inter- and intra-observer agreement for the determination of the Singh index.

Even the distance between a patient and X-ray tube, and the type of radiographs films, could influence the quality and resolution of the images.

There were no significant correlations between the Singh index and other parameters such as age, weight, pregnancy number. However, there were significant negative correlations between BMD and parameters such as age and pregnancy number.

It seems that, the only advantage of the Singh index is its high sensitivity for screening. The reason that some authors of some articles have confirmed the Singh index for the diagnosis of osteoporosis could had been to the lack of DXA bone densitometers at their times of investigation.

Finally, we recommend comparing the Singh index with the QCT and QUS techniques for screening of osteoporosis.

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