Singh Index Screening for Femoral Neck Osteoporosis

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*The present study included 130 elderly women living in Khon Kaen, Thailand, and all but one underwent both DEXA-BMD and AP radiographs of the left hip joint. The mean (SD) of age, weight, height and BMI of the 129 participants was 72.5 (5.3) years, 49.8 (10.3) kg, 1.49 (0.06) m, and 22.21 (4.13) kg/m^2, respectively. The authors found both poor sensitivity and a positive predictive value for a Singh grade of ≤ 4 or ≤ 3 (*viz. *58 and 29 or 19 and 43 percent, respectively). The ROC curve showed the poor diagnostic value of the Singh index since the area under the curve was ~40% †the Singh index is therefore a poor screening tool for femoral neck osteoporosis.*

Keywords: *Singh index; Diagnostic test; Screening tool; Osteoporosis; Bone Mineral Density.*

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Osteoporotic hip fractures constitute a major public health problem in both developed and developing countries because of associated morbidity, mortality and cost. It is estimated that about 1.7 million hip fractures occurred worldwide in 1990 and about one-third were in Asia[1].

Due to various sequelae, 25% of hip fracture victims die within 6 months of the event, and mortality rises progressively with age. Among survivors, fewer than 50% regain their former level of mobility such that the majority is unable to cope with daily living unaided[2,3]. Most of the costs from osteoporosis are attributable to hip fractures because of the need for hospitalization and/or nursing-home care.

The techniques used to assess the risk of fractures include: 1) clinical assessment of risk factors and 2) physical measurement of skeletal mass. Skeletal mass can be measured by semi-quantitative techniques for assessing the trabecular morphology of the femoral neck (*i.e.* the Singh index), radiogrammetry, radiographic absorptiometry, quantitative computed tomography, ultrasonography, or by energy absorptiometry (*e.g.* dual energy X-ray absorptiometry (DEXA) or single energy X-ray absorptiometry (SEXA)).

DEXA is presently the best method for measuring bone mass because of its high accuracy and low precision error, but it is expensive. A more widely available and less expensive screening tool is conventional radiography used in conjunction with the Singh index.

The Singh index has been criticized for its low reliability due to the subjective nature of its ill-defined grading of[4,5], and cut-off level for[6,7], osteoporosis. The objective of the present study was to compare the gold standard BMD with the Singh index to evaluate the presence or absence of osteoporosis on the same side of the femoral neck as *per* WHO criteria. The sensi-tivity, specificity, positive and negative predictive values, and the ROC curve would be calculated (for the best cut-off point for the Singh index).

Material and Method

The participants were elderly women living in Khon Kaen, Thailand. Included were healthy women over 60 who had given informed, written consent to participate in the present study. Women with bone tumors, metabolic bone disease, infection, inflammation, an old dislocation or previous fracture of the hip joint, debilitating patients were excluded.

The bone mineral density of the left femoral neck was measured at Srinagarind Hospital, Khon Kaen University, using DEXA (Prodigy,Lunar Corp,USA) with a precision error of 1-2%.

The antero-posterior hip radiographs were confined to the left hip joint with neutral flexion, abduction and 15°internal rotation. Two radiologists assigned a Singh grading (between 6 and 1) to each radiograph twice at least 1 month apart. The radiologists were not apprised of each other's ratings nor

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reminded of their own first rating. The six grades were assigned using reference radiographic charts of the Singh index method (Fig. 1). The inter- and intra-personal reliability of the evaluations (kappa) were tested. A consensus Singh grading was given should the radiologists disagree before any comparison with the BMD was allowed.

Presented in tabular form is the sensitivity, specificity, positive and negative predictive values. Also shown are the ROC curves used to establish the cut-off level for the Singh index for the evaluation of femoral neck osteoporosis, which was then compared with the BMD (*i.e.* the gold standard) of the same side of the femoral neck.

A minimum sample size of 123 participants was calculated on the premise that: 1) the Singh index (a screening tool for femoral neck osteoporosis) has a Type I error of 0.05; 2) the prevalence of osteoporosis in the sample population is 40%; 3) the sensitivity for diagnosis is 85%; and, 4) the acceptable error is 10%.

Figure of Singh Index	Detail 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: The structure of principal tensile and 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.
	Grade 2: Only the principal compressive trabeculae stand out prominently, the others have been more or less completely resorbed.
	Grade 1: Even the principal compressive trabeculae are markedly reduced in number and are no longer prominent.

Fig. 1 Singh index reference radiographs and their descriptions

Results

All 130 enrollees underwent left hip radiographs and all but one underwent both a BMD measurement and left hip radiograph. The women were between 62 and 87 years of age. The baseline clinical characteristics of the participants (*i.e.* age, weight, height and BMI) are presented in Table 1.

Table 2 shows the distribution of each Singh grading level, and the amount and percentage of osteoporosis. All of the participants had a Singh grade of between 3 and 6; grades 1 and 2 were not found.

Table 3 presents the sensitivity, specificity, positive and negative predictive values for a Singh grade 5 or less to grade 3 or less for diagnosis of femoral neck osteoporosis compared with the gold standard DEXA-BMD.

Figure 2 shows the ROC curve, the plot of sensitivity and '1-specificity' for each Singh grade. The curve was a diagonal and the area under the curve was ~40%.

Table 1. Baseline clinical characteristics (n=129 cases)

	Mean (SD)
Age (years)	72.47 (5.29)
Weight (kg)	49.81 (10.29)
Height (m)	1.49 (0.06)
BMI (kg/m^2)	22.21 (4.13)

Table 2. Total amount of each Singh grading, the amount and percentage of osteoporosis and non-osteoporosis

Singh grading	Percent with osteoporosis	Percent of non-osteoporosis
Grade 6 (8 cases)	1 (0.78)	7 (5.43)
Grade 5 (59 cases)	12 (9.3)	47 (36.43)
Grade 4 (48 cases)	12 (9.3)	36 (27.91)
Grade 3 (14 cases)	6 (4.65)	8 (6.2)
Total (129 cases:100%)	31 (24.03)	98 (75.97)

Table 3. Sensitivity, specificity, positive (PPV) and negative (NPV) predictive values for each Singh grading

Singh grading	Sensitivity	Specificity	1-specificity	PPV	NPV
≤ Grade 5	0.97	0.07	0.93	0.25	0.88
≤ Grade 4	0.58	0.55	0.45	0.29	0.81
≤ Grade 3	0.19	0.92	0.08	0.43	0.78

PPV= post-test probability of a positive test
NPV= post-test probability of a negative test

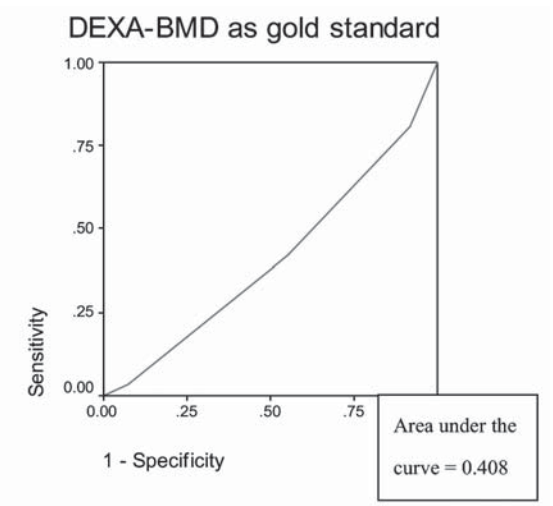

Fig. 2 The ROC curve of Singh index in diagnosing femoral neck osteoporosis using the DEXA-BMD of femoral neck as the gold standard. The area under the curve is less than 50%

Discussion

In 1970, Singh *et al*[6] demonstrated how the trabecular patterns of the proximal femur were disturbed in the course of osteoporosis. They then described six trabecular patterns: grade six representing a normal pattern, grade 4 osteopenia and grades 3 and lower increasing degrees of osteoporosis. A good correlation between the histological findings of iliac crest biopsy with this grading system was reported. The pattern of trabecular loss provided a semi-quantitative estimate of osteoporosis, which would be a valuable tool in epidemiological studies.

The six grades could be distinguished by reference radiographs (Fig. 1), which include a detailed description of the grading technique[8], and suggested that accurate grading requires a roentgenogram of the hips in a neutral flexion, abduction and 15∞ internal rotation. The authors used these reference radiograph charts for Singh index grading, and all participants had left hip radiographs in the positions suggested: nevertheless, the authors found poor intra- and inter-observer reliability (kappa), *viz.*: 0.15 *vs.* 0.29 and 0.10, respectively[9].

If one were to set a Singh grade of ≤ 4 for ' osteoporosis', the sensitivity and specificity of the Singh index for diagnosing osteoporosis would be 58 and 55 compared to 19 and 92 percent, respectively, for a definition set at a Singh of ≤ 3. The authors found the Singh index had a poor sensitivity (*the same as* Masud *et al*[7]). Furthermore, it also had a low positive predictive value (ppv for a grade of 4 or less = 0.29 *vs.* 0.43 for a grade of 3 or less).

From the ROC curve, the area under the curve was < 50% and the curve was a near perfect diagonal (Figure 2) confirming that the Singh index has little diagnostic value for osteoporosis, especially for screening osteoporosis of the femoral neck.

Conclusion

The Singh index has poor reliability and poor diagnostic value in screening of femoral neck osteoporosis.

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การใช้ Singh index เพื่อคัดกรองโรคกระดูกพรุนของคอกระดูกต้นขา

ศุภศิลป์ สุนทราภา, สุกรี สุนทราภา, จิราภรณ์ ศรีนัครินทร์, ปรารถนา เชาวน์ชื่น

สตรีสูงอายุทั้งหมดในการศึกษานี้จำนวน 130 ราย อาศัยอยู่ในจังหวัดขอนแก่น มี 129 รายที่ได้รับการตรวจทั้งความหนาแน่นของคอกระดูกต้นขาและถ่ายรังสีเอกซ์ของข้อสะโพกซ้าย ค่าเฉลี่ย (ค่าเบี่ยงเบนมาตรฐาน) ของอายุ น้ำหนัก ส่วนสูงและค่าดรรชนีมวลกายของผู้สูงอายุจำนวน 129 รายนี้มีค่า 72.47 (5.29) ปี 49.81 (10.29) ก.ก. 1.49 (0.06) ม. และ 22.21 (4.13) ก.ก./ม^2 ตามลำดับ จากการศึกษาพบว่าค่าความไว (sensitivity) และค่า positive predictive value ของ Singh index ระดับ 4 หรือน้อยกว่าและระดับ 3 หรือน้อยกว่ามีค่าค่อนข้างต่ำ โดยพบว่ามีค่าความไวร้อยละ 58 และ 19 ตามลำดับ และค่า positive predictive value ร้อยละ 29 และ 43 ตามลำดับ นอกจากนี้ยังพบว่าจากเส้นโค้ง ROC แสดงให้เห็นถึงความสามารถในการวินิจฉัยโรคของ Singh index มีค่าค่อนข้างต่ำ โดยพบว่ามีพื้นที่ใต้เส้นโค้งเพียงประมาณร้อยละ 40 เท่านั้นและเส้น ROC นี้เกือบจะเป็นเส้นทแยงมุม จากผลการศึกษาทั้งหมดแสดงให้เห็นได้ว่า Singh index ถือเป็นเครื่องมือคัดกรองโรคกระดูกพรุนของคอกระดูกต้นขาที่เลว