Modified Singh Index in Diagnosing Femoral Neck Osteoporosis

Sukree Soontrapa MD* ,
Suppasin Soontrapa MD**

** Departments of Obstetrics and Gynecology, Faculty of Medicine, Khon Kaen University, Khon Kaen, Thailand*
*** Departments of Orthopaedics, Faculty of Medicine, Khon Kaen University, Khon Kaen, Thailand*

The participants in the present study were 130 elderly women living in Khon Kaen, Thailand. All except one subject was undergone by both DEXA-BMD and AP radiographs of the left hip joints. The mean (SD) of age, weight, height and BMI of the 129 participants were 72.5 (5.3) years old, 49.8 (10.3) kg, 1.49 (0.06) m, and 22.21 (4.13) kg/m^2, respectively. Poor intrapersonal reliability (kappa = 0.11 and 0.11) and poor interpersonal reliability (kappa = 0.15) for the modified Singh index with three grades were found. On the other hand the modified Singh index with two grades had high accuracy in diagnosing of femoral neck and total hip osteoporosis (0.74 and 0.81 respectively) when comparing with DEXA-BMD.

***Keywords**: Modified; Singh index; Diagnostic test; Screening tool; Osteoporosis*

J Med Assoc Thai 2011; 94 (Suppl. 5): S79-S83
***Full text. e-Journal:** http://www.mat.or.th/journal*

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 consequences, 25% of hip fracture victims die within 6 months of the event and mortality rises progressively along with age. Among survivors, fewer than 50% regain their former level of mobility; 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 fracture include: 1) clinical assessment of risk factors and 2) physical measurement of skeletal mass. The skeletal mass can be measured by semi-quantitative techniques for assessing the trabecular morphology of the femoral neck, radiography, or the Singh index, radiogrammetry, radiographic absorptiometry, quantitative computed tomography, quantitative ultrasonography, or by energy absorptiometry, *e.g.* single energy x-ray absorptiometry (SEXA) or dual energy x-ray absorptiometry (DEXA). 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 trabecular pattern as in the Singh index.

The Singh index has been criticized for its low reliability due to the subjective nature of its ill-defined grading[4,5], and the cut-off level for[6,7] osteoporosis. Our previous studies[8,9] showed that the Singh index was a poor screening tool for femoral neck osteoporosis due to its poor sensitivity, poor positive predictive value, and low area under ROC curve.

In the present study, grading in the Singh index had been modified by decreasing the number of grading for more convenience and ease for grading. The objective of the present study was to evaluate the reliability of the new modified Singh index in diagnosing femoral neck osteoporosis by using DEXA-BMD as gold standard.

Material and Method

A sample size has been calculated on the assumption that 1) the modified Singh index has a type I error of 0.05; 2) the prevalence of osteoporosis in this sample population is 40%; 3) the sensitivity for

Correspondence to:
Soontrapa S, Department of Obstetrics and Gynecology, Faculty of Medicine, Khon Kaen University, Khon Kaen 40002, Thailand.
Phone: 043-363-029, 043-363-030
E-mail: sugsoo@kku.ac.th

diagnosis is 85%; and 4) the acceptable error is 10%.

The participants were 130 healthy elderly women living in Khon Kaen, Thailand. They were over 60 years old and handed the informed written consent to participate in the present study. The women with bone tumors, metabolic bone disease, infection, inflammation, an old dislocation or previous fracture of the hip joint, and debilitating patients were excluded.

The bone mineral density of the left femoral neck was measured by using DEXA (Prodigy, Lunar Corp, USA) with a precision error of 1-2% at Srinagarind Hospital, Khon Kaen University. The antero-posterior hip radiographs were performed to the left hip joint with neutral flexion abduction and 15° internal rotations in order to get the true AP view of femoral neck. All radiograph was undergone the quality control by radiologists. The three grades of modified Singh index were in Fig. 1. Two clinicians, a research gynecologist and a research orthopedist, who did not know the results of DEXA-BMD were assigned grading independently according to the modified model (grade between 0 and 2) to each radiograph occurring twice about two months apart, without reminding of their own previous grading. Finally, a consensus grading was given once by the agreement of the same two clinicians in about two months later.

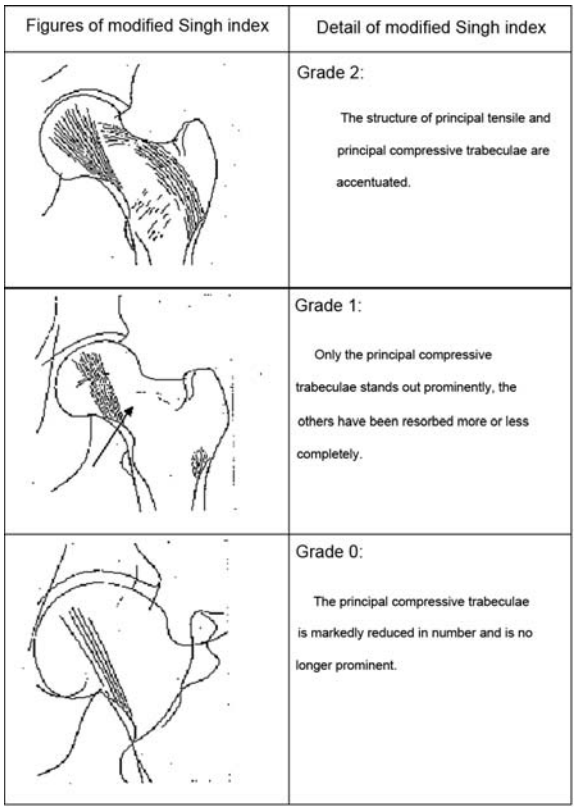

Fig. 1 Figures of modified Singh index and their descriptions

Data analysis

The demographic data of the participants was shown as the mean ± standard deviation (SD). The reliability of the new modified grading of Singh index compared to the DEXA-BMD, both intrapersonal and interpersonal reliability were shown as kappa and 95% confident interval. The diagnostic values were presented as sensitivity, specificity, positive and negative predictive values, accuracy and ROC curve.

Results

One hundred and thirty elderly women were recruited; one elderly woman was excluded due to the absence of examination by DEXA. The participants were between 62 and 87 years of age. The baseline clinical characteristics of the participants were presented in Table 1.

The interpersonal and intrapersonal reliability of the modified (three grades) Singh index as shown in Fig. 1 (kappa) were tested. The present study found that both intrapersonal agreement (kappa of the gynecologist = 0.11, 95% CI -0.01 and 0.23 and kappa of the orthopedist = 0.11, 95% CI -0.06 and 0.28) were poor and the interpersonal agreement (kappa = 0.15, 95% CI 0.00 and 0.30) was also poor. So, the researchers decreased grading to be only two grades: Grade 0 = osteoporosis and Grade 1 = non-osteoporosis by focusing only on the compression trabeculae. If the discontinuity of the compression trabeculae was more than 50%, it was defined as Grade 0 and the other was Grade 1.

Table 2 showed the distribution of each agreed grading of modified (two grades) Singh index and the amount (percent) of osteoporosis and non-osteoporosis by DEXA-BMD.

Table 3 presented the sensitivity, specificity,

Table 1. Baseline of the 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)

positive predictive value, negative predictive value, and accuracy of modified (two grades) Singh index for diagnosis of osteoporosis of various parts of bone compared with DEXA-BMD as gold standard.

Fig. 2 showed the ROC curve, the plot of sensitivity and 1-specificity for each modified (two grades) Singh index grading in diagnosing femoral neck osteoporosis using the DEXA-BMD of femoral neck as gold standard. The area under the curve is 68%.

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 6 representing a normal pattern, Grade 4 showing osteopenia, and Grade 3 and lower indicating the increasing degree of osteoporosis. A good correlation between the histological findings of iliac crest biopsy with this grading system was also reported. Besides, the pattern of trabecular loss provided a semi-quantitative estimation of osteoporosis which would be a valuable tool in epidemiological studies.

The six grades could be distinguished by reference radiographs which included a detailed description of the grading technique[10] and suggested that accurate grading requires a roentgenogram of the hips in neutral flexion, abduction and 15° internal rotation.

In our previous studies[8,9], the authors found poor intrapersonal reliability (kappa = 0.15 and 0.29) and interpersonal reliability (kappa = 0.10), but the reliability in weighted kappa was higher in both intrapersonal reliability (kappa = 0.27 and 0.35) and interpersonal reliability (kappa = 0.26). The authors found that if the Singh index of grade ≤ 4 were set to be osteoporosis, instead of Singh index grade ≤ 3, the sensitivity would increase to be 58 % compared to 19 %. The specificity consequently would decrease to be 55 % compared to 92 %.

In the present study, the researchers evaluated the modified Singh index of which the grading was decreased from six grades to be three grades in order to

Table 2. Distribution of each agreed grading of modified (two grades) Singh index and the amount (percent) of osteoporosis and non-osteoporosis by DEXA-BMD

Modified Singh grading	Number (Percent) of osteoporosis	Number (Percent) of non-osteoporosis
Grade 0	18 (13.95)	21 (16.28)
Grade 1	13 (10.08)	77 (75.97)
Total	31 (24.03)	98 (76.97)

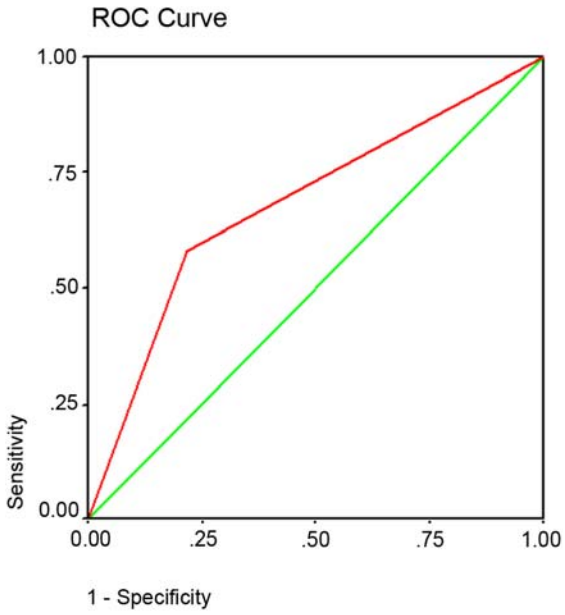

Fig. 2 The ROC curve of modified (two grades) Singh index in diagnosing femoral neck osteoporosis (the area under the curve was 68%)

Table 3. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy of modified (two grades) Singh index for diagnosis of osteoporosis of various parts of bone

	Sensitivity	Specificity	PPV	NPV	Accuracy
Femoral neck	0.58	0.78	0.46	0.86	0.74
Total hip	0.77	0.82	0.53	0.93	0.81
Spine	0.47	0.88	0.82	0.60	0.67
Ultra distal radius	0.38	0.91	0.92	0.34	0.52
Distal radius	0.41	0.89	0.87	0.46	0.58

increase the agreement of grading. However, the results of the present study also showed no increasing of the agreement in grading from both intrapersonal (k = 0.11 and 0.11) and interpersonal reliability (k = 0.15). After the researchers decreased the modified Singh index from three grades to be only two grades by focusing only on the compression trabeculae, the diagnostic power were markedly improved especially in diagnosing osteoporosis of femoral neck (the accuracy was 0.74) and total hip (the accuracy was 0.81) when comparing with DEXA-BMD as shown in Table 3. Furthermore, it also had higher accuracy in the area under the ROC curve as shown in Fig. 2. This showed that modified Singh index with two grades would be valuable to be a screening tool in osteoporosis diagnosis of femoral neck including total hip. Further investigation and clinical utilization need to be more conducted.

Conclusion

The two grading of modified Singh index had high accuracy in diagnosis of femoral neck and total hip osteoporosis when comparing with DEXA-BMD.

Potential conflicts of interest

The present study was supported by a research grant from the Faculty of medicine, Khon Kaen University.

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การวินิจฉัยโรคกระดูกพรุนของคอกระดูกต้นขาโดยใช้ modified Singh index

สุกรี สุนทราภา, ศุภศิลป์ สุนทราภา

การศึกษาครั้งนี้มีผู้ร่วมโครงการเป็นสตรีสูงอายุจำนวน 130 ราย ซึ่งอาศัยอยู่ในจังหวัดขอนแก่น ทุกคน (ยกเว้น 1 ราย) ได้รับการตรวจทั้งความหนาแน่นของกระดูกบริเวณคอกระดูกต้นขาโดยใช้เครื่อง DEXA และถ่ายภาพรังสีเอกซ์ ของข้อกระดูกสะโพกซ้าย ค่าเฉลี่ย (ค่าเบี่ยงเบนมาตรฐาน) ของอายุ น้ำหนัก ส่วนสูง และค่าดัชนีมวลกายของผู้สูงอายุ จำนวน 129 ราย มีค่า 72.5 (5.3) ปี 49.8 (10.3) กก. 1.49 (0.06) ม. และ 22.21(4.13) กก./ม.^{2} ตามลำดับ

ผลการศึกษาครั้งนี้พบว่า เมื่อทำการปรับลด Singh index จาก 6 ระดับเป็น 3 ระดับ ยังคงพบว่ามีค่าความน่าเชื่อถือต่ำทั้งภายในบุคคลเดียวกัน (k = 0.11 และ 0.11) และต่างบุคคลกัน (k = 0.15) แต่เมื่อปรับลด modified Singh index จาก 3 ระดับเหลือเพียง 2 ระดับ กลับพบว่าค่า modified Singh index 2 ระดับนี้มีความแม่นยำ (accuracy) ดีขึ้น โดยพบว่าความแม่นยำเมื่อเทียบกับการใช้ DEXA ในการวินิจฉัยโรคกระดูกพรุนของคอกระดูกต้นขา (femoral neck) และกระดูกสะโพกทั้งหมด (total hip) มีค่า 0.74 และ 0.81 ตามลำดับ