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Exploring the Predictive Capability of Osteoporosis Self-Assessment Tool for Asians Score for Fragility Fractures: A Retrospective Cohort Analysis

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ABSTRACT

OBJECTIVE: The primary objective of the present study was to evaluate the predictive efficacy of the Osteoporosis Self-Assessment Tool for Asians (OSTA) in identifying individuals predisposed to fragility fractures.

METHODS: This retrospective cohort study involved 17,189 adults aged 50 years and older. We examined the relationship between osteoporosis risk and fragility fractures to establish fundamental insights into fragility fracture risk factors. Data were collected from the outpatient orthopedic department. The incidence rates (IRs) per person-year at risk were calculated based on the initial diagnosis of fragility fractures. Poisson regression analysis was used to ascertain the IR ratios (IRR), with adjustments made for factors including age, sex, income, occupation, comorbidities, and estrogen supplementation.

RESULTS: Among the 17,189 patients identified as healthy adults at baseline, 6,996 fragility fractures were recorded. The adjusted IRR for documented fragility fractures demonstrated a significant elevation among individuals categorized as medium or high risk for osteoporosis displayed a 1.24-[95% confidence interval (CI) 1.15-1.33] and 1.66-fold (95% CI = 1.51-1.83), respectively.

CONCLUSION: Our results highlight the increased risk of fragility fractures associated with medium and high-risk osteoporosis, as evaluated by OSTA and provide insights into potential strategies for mitigating the anticipated public health impact of osteoporotic fractures.

KEYWORDS: fragility fracture, incidence, osteoporosis, Osteoporosis Self-assessment Tool for Asians, primary care

INTRODUCTION

Osteoporosis is characterized by the deterioration of bone mass and microarchitecture, leading to reduced bone strength and increased vulnerability to fragility fractures[1]. The prevalence of osteoporosis among Thai males was recorded at 12.6% and 4.6% at the femoral neck and lumbar spine, respectively. Furthermore, the prevalence of osteoporosis among early postmenopausal women seeking care at a tertiary care hospital's menopausal clinic was determined to be 21.3%[2]. Fractures attributable to osteoporosis are often due to low-impact incidents such as falls from a standing height or those which under ordinary circumstances would not cause fractures[3]. The age-adjusted incidence of hip fracture demonstrated an annual increase of 2%, rising from 192.9 (males: 110.8; females: 272.1)

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to 253.3 (males: 135.9; females: 367.9) per 100,000 person-years (PY)[2]. However, the delineation of osteoporotic fractures is not unequivocal and occasionally engenders misconceptions. Despite comprehensive studies demonstrating increased fracture incidence across various anatomical sites in individuals with diminished bone mineral density (BMD) regardless of location[3], reliance solely on low BMD may inadequately discern the propensity for osteoporotic fractures[3], as fractures may occur independently of diminished BMD[4]. Moreover, bone fragility did not appear to play a role in fractures resulting from high-impact trauma. A comparative analysis investigating the BMD of women who experienced fractures from either low- or high-level traumatic events revealed that under high-energy trauma scenarios, individuals with osteoporosis demonstrated increased susceptibility to fractures compared to those without osteoporosis[5].

Understanding the epidemiology of fragility fractures, notably hip fractures, which are linked to increased mortality and disability rates[4], has been a central focus of research, resulting in varied findings across diverse global regions[6]. While female sex and advanced age are firmly established risk factors for osteoporosis, the impact of other demographic parameters remains unclear. Notably, a recent systematic review highlighted the correlation between socioeconomic status and risk of fragility fractures[7]. Therefore, our research, leveraging routinely collected data, sought to elucidate the recording practices regarding osteoporosis and fragility fractures. Concurrently, we aimed to investigate the trends in incidence rates (IRs) across various sociodemographic strata. Insight into the patterns of documented osteoporosis diagnoses is of paramount importance in formulating and implementing public health initiatives and community-based interventions aimed at preventing fragility fractures in the elderly population.

BMD evaluation in the lumbar spine and hip is currently the primary approach for diagnosing osteoporosis. Extensive research has established a strong association between low BMD and major osteoporotic fractures, including those affecting the spine[8], hip[9], humerus[10], and forearm[10]. Given the well-documented correlation between advanced age, reduced body weight, low BMD, and increased fracture risk[6], the World Health Organization developed the Osteoporosis Self-Assessment Tool for Asians (OSTA) score. The OSTA score is computed using body weight and age [(body weight in kilograms–age in years) multiplied by 0.2], and it aims to identify women at risk for osteoporosis[11]. In a proof-of-principle study, OSTA demonstrated superior performance compared to alternative osteoporotic indices, showing a sensitivity of 91%, specificity of 45%, and a receiver operating characteristic curve of 0.79 at a cutoff value of -1[11]. Additionally, minimal disparities in OSTA performance were observed across femoral neck and lumbar spine BMD reference points at the -1 cutoff threshold[12]. By stratifying patients into low- (OSTA > -1), medium- (-1 ≥ OSTA ≥ -4), and high-risk (OSTA < -4) categories for osteoporosis susceptibility[11], it is estimated that individuals with an OSTA score exceeding -4 have a 99.3% probability of not having osteoporosis[13]. With robust validation across populations in Taiwan, China, Korea, Singapore, Malaysia, Thailand, and the Philippines, OSTA has emerged as a dependable and practical screening tool for identifying patients at risk of osteoporosis[14].

The current investigation sought to assess the predictive accuracy of the OSTA in discerning individuals prone to fragility fractures.

METHODS

The Phramongkutklao Hospital Database (PHD) program is a comprehensive system that facilitates access to patient data within Phramongkutklao Hospital, Bangkok, Thailand. For this investigation, a subset of the PHD was utilized, comprising extensive healthcare records pertaining to the ambulatory care services offered by the orthopedic outpatient department. These datasets were randomly sampled from all patients seeking care. Importantly, these datasets can be

linked via encrypted and unique personal identification numbers, thereby enabling the establishment of longitudinal medical histories of individual patients. Diagnostic classification was performed in accordance with the International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM). Approval for this study was obtained from the Institutional Review Board of the Royal Thai Army Medical Department (IRBTA0269/2024).

A retrospective cohort analysis was performed to investigate the association between fragility fractures and osteoporotic risk, which was evaluated using OSTA. The investigation was conducted at Phramongkutklao Hospital, affiliated with Phramongkutklao College of Medicine, in Bangkok, Thailand from January 2009 to December 2023. The inclusion criteria for patients diagnosed with fragility fractures included hip, spine, pelvis, femur (thigh), wrist, and humeral (arm) fractures. These fractures were identified using the ICD-10-CM codes M80.x, M84.3, and M84.4. New-onset osteoporosis diagnoses from 2009 to 2023 were ascertained based on primary discharge diagnoses. The exclusion criteria for the study were individuals aged < 50 years; those with a documented history of prior fractures; individuals with a history of smoking, alcohol addiction, systemic glucocorticoid use, or rheumatoid arthritis at baseline; and those with traumatic fractures resulting from accidents (such as car accidents or falls from heights above chair level), pathological fractures associated with cancer, or fractures affecting the fingers, toes, ankles, face, or skull. Individuals diagnosed with osteoporosis were excluded. Among the 17,189 patients meeting the inclusion criteria, which included 15,525 females, 6,996 were diagnosed with fragility fractures and included in the analysis. Patients without osteoporosis were randomly selected from the PHD to form a comparison cohort. All participants were tracked until December 31, 2023, or until they experienced loss to follow-up, mortality, or voluntary withdrawal from the healthcare system.

The study encompassed various variables, including age (grouped into 50–65 years and > 65 years), sex (male or female), and income. Baseline comorbidities were identified using the ICD-10-CM and Anatomical Therapeutic Chemical (ATC) codes for medications. The specific comorbidities examined included stroke (ICD-10-CM codes: I60-I66), hypertension (ICD-10-CM codes: I10-I15), type 2 diabetes mellitus (ICD-10-CM code: E11), dementia [ICD-10-CM codes: F00, F00.(1,2,9), F01, F01.(0,1,2,3,8,9), F02, F02.(0,1,2,3,4,8), and F03], Alzheimer's disease (ICD-10-CM: G30), depressive disorder [ICD-10-CM codes F32 and F32.(0,1,2,3,8,9), and F33.(0,1,2,3,4,8,9)]. Additionally, this study considered the use of estrogen (ATC codes: T385, Y425, EST103N, PRO108E, and ANG103N), calcium supplementation (ATC codes: CHA103E, CHA106E, CAL107N, and VIT112E), and vitamin D2 supplementation at a dose of 20,000 IU (calciferol; ATC code, VIT112E).

Previous studies have indicated that individual-based low socioeconomic status (SES) is associated with an increased risk of fragility fractures, with a relative risk (RR) of 1.27 (95% confidence interval (CI) 1.12, 1.44)[15]. Furthermore, the overall risk of mortality within one year post-hip fracture in individuals with low SES was found to be 24% higher compared to those with high SES (RR 1.24, 95% CI 1.19 to 1.29) for individual-level SES measures[16]. Therefore, in this study, socioeconomic status, represented by income, is considered an important factor to investigate, as it increases the risk of fragility fractures. In the table, "With Income" means having income, and "No Income" means having no income.

The IR of fragility fractures was determined per PY. This involved compiling the number of patients with an initial recording of the diagnostic read code for fragility fracture and osteoporosis recruitment from 2009 to 2023, followed by dividing this total by the aggregate PY of follow-up across all patient records during this timeframe. IRs were stratified by age, sex, socioeconomic status, and calendar year of diagnosis. Poisson regression analysis was performed to compare

IRs and provide adjusted IR ratios, accounting for age, sex, income, and calendar year. Likelihood ratio tests were performed to investigate potential interactions among the covariates. Statistical analyses were performed using the IBM SPSS statistics software (version 26.0; IBM, Armonk, NY, USA).

RESULTS

Table 1 presents the sociodemographic characteristics and baseline comorbidity status of patients in the fragility and non-fragility fracture cohorts. Within both cohorts, approximately 4.9% of patients were identified as experiencing no income, while 11.2% fell within the underweight range [body mass index (BMI) < 18.5], and 13.8% were classified as high risk for osteoporosis (OSTA < -4). Additionally, all patients exhibited low levels of vitamin D. Patients with fragility fractures demonstrated a higher prevalence of dementia (8.2% vs. 5.3%, p < 0.001), stroke (5.2% vs. 3.9%, p < 0.001), and hypertension (64.7% vs. 62%, p < 0.001) compared to patients without fragility fractures. Moreover, the proportion of patients receiving estrogen and calcium supplementation was significantly lower among those with fragility fractures than among those without.

Table 1 Comparison of baseline characteristics between patients with and without fragility fractures

Characteristics		Fragility fractures			
		No	Yes	Total	P-value
Total		10193	6996	17189	
Age (years)		75.2 ± 9.8	78.6 ± 10	76.6 ± 10	< 0.001*
Sex	Female	8884 (87.2%)	6341 (90.6%)	15225 (88.6%)	< 0.001*
	Male	1309 (12.8%)	655 (9.4%)	1964 (11.4%)	
OSTA	High	1019 (10%)	1343 (19.2%)	2362 (13.8%)	< 0.001*
	Medium	3129 (30.6%)	2505 (35.8)	5634 (32.8)	
	Low	6045 (59.4%)	3148 (45%)	9193 (53.4%)	
Income	With income	9637 (94.5%)	6715 (96%)	16352 (95.1%)	< 0.001*
	No Income	556 (5.5%)	281 (4%)	837 (4.9%)	
BMI (kg/m^2)	< 18.5	576 (9.7%)	553 (13.2%)	1129 (11.2%)	< 0.001*
	18.5-22.9	2444 (41.1%)	1797 (43.1%)	4241 (41.9%)	
	23-24.9	1269 (21.3%)	785 (18.8%)	2054 (20.3%)	
	25-29.9	1344 (22.6%)	813 (19.5%)	2157 (21.3%)	
	≥ 30	315 (5.3%)	226 (5.4%)	541 (5.3%)	
Dementia	No	9649 (94.7%)	6424 (91.8%)	16073 (93.5%)	< 0.001*
	Yes	544 (5.3%)	572 (8.2%)	1116 (6.5%)	
Stroke	No	9794 (96.1%)	6634 (94.8%)	16428 (95.6%)	< 0.001*
	Yes	399 (3.9%)	362 (5.2%)	761 (4.4%)	
Depressive	No	9835 (96.5%)	6746 (96.4%)	16581 (96.5%)	0.864
	Yes	358 (3.5%)	250 (3.6%)	608 (3.5%)	
Type 2 Diabetes mellitus	No	10019 (98.3%)	6856 (98%)	16875 (98.2%)	0.175
	Yes	174 (1.7%)	140 (2%)	314 (1.8%)	
Hypertension	No	3871 (38%)	2470 (35.3%)	6341 (36.9%)	< 0.001*
	Yes	6322 (62%)	4526 (64.7%)	10848 (63.1%)	
Estrogen supplementation	No	10060 (98.7%)	6964 (99.5%)	17024 (99%)	< 0.001*
	Yes	133 (1.3%)	32 (0.5%)	165 (1%)	
Calcium supplementation	No	808 (7.9%)	398 (5.7%)	1206 (7%)	< 0.001*
	Yes	9385 (92.1%)	6598 (94.3%)	15983 (93%)	

Abbreviations: BMI, body mass index; kg/m^2, kilogram per square meter; OSTA, osteoporosis self-assessment tool for Asians
*P-value < 0.001

Table 2 illustrates that patients classified as medium- or high-risk for osteoporosis based on OSTA, with or without comorbidities, were associated with an increased risk of fragility fractures compared with those categorized as low risk for osteoporosis. Specifically, patients identified as medium or high risk for osteoporosis displayed a 1.24-[95% CI = 1.15-1.33] and 1.66-(95% CI = 1.51-1.83) higher risk of developing fragility fractures, respectively, compared to patients categorized as low risk for osteoporosis. Female patients exhibited a 1.38-fold (95% CI = 1.23-1.54) higher risk of fragility fractures compared to male patients. The risk of osteoporotic fractures differs significantly between males and females, with females generally having a higher risk due to factors such as post-menopausal estrogen decline affecting bone density[17]. The OSTA index is primarily designed to assess fracture risk in females[18]. However, when applied to males, it necessitates a different cutoff value to account for differences in bone structure and density between genders. Adjusting the cutoff value for males may result in changes in the assessed fracture risk, potentially leading to more accurate identification of high-risk individuals and better-targeted prevention and treatment strategies. Additionally, patients with a history of stroke or hypertension were associated with a 1.15-(95% CI = 1.02-1.31) and 1.1-fold (95% CI = 1.03–1.18) higher risk of developing fragility fractures, respectively. Analysis of the effects of medication on fragility fracture risk revealed that patients receiving estrogen supplementation exhibited a 0.69-fold lower risk of fragility fractures than those who did not receive any treatment (p = 0.039).

Table 2 Comparison of incident rate ratios between patients with high, medium and low risk of osteoporosis for fragility fracture outcomes

Characteristics		Crude IR (95% CI)	P-value	Adjusted* IRR (95% CI)	P-value
Female		1.33 (1.23-1.44)	< 0.001*	1.38 (1.23-1.54)	< 0.001*
OSTA	High	1.96 (1.81-2.13)	< 0.001*	1.66 (1.51-1.83)	< 0.001*
	Medium	1.39 (1.3-1.49)	< 0.001*	1.24 (1.15-1.33)	< 0.001*
Age > 65 years		1.52 (1.41-1.63)	< 0.001*	1.13 (0.99-1.29)	0.071
No income		1.33 (1.18-1.49)	< 0.001*	0.88 (0.71-1.09)	0.247
BMI < 18.5 kg/m^2		1.28 (1.17-1.4)	< 0.001*	0.94 (0.85-1.04)	0.217
Stroke		1.24 (1.12-1.38)	< 0.001*	1.15 (1.02-1.31)	0.029**
Depressive disorder		1.02 (0.9-1.15)	0.783	1.11 (0.95-1.28)	0.186
Type 2 Diabetes mellitus		1.05 (0.89-1.25)	0.538	1.08 (0.9-1.3)	0.383
Hypertension		1.1 (1.04-1.15)	< 0.001*	1.1 (1.03-1.18)	0.039**
Estrogen supplementation		0.42 (0.3-0.59)	< 0.001*	0.69 (0.48-0.98)	0.039**
Calcium supplementation		1.29 (1.16-1.42)	< 0.001*	1.17 (0.93-1.47)	0.173

Abbreviations: BMI, body mass index; CI, confidence interval; IR: incidence rate; IRR: incidence rate ratio; kg/m^2, kilogram per square meter; OSTA, osteoporosis self-assessment tool for Asians
*P-value < 0.001; **P-value < 0.05

DISCUSSION

Osteoporosis is a pervasive global health issue with a steadily increasing prevalence, posing a mounting burden on society. Regrettably, its insidious nature often renders it asymptomatic until the occurrence of fractures, highlighting the critical need for early detection and assessment of associated risk factors. Such endeavors hold considerable significance in mitigating the profound impact of osteoporosis-related complications on public health. This study conducted in the Thai population sheds light on pertinent demographic associations, offering valuable insights into the epidemiological landscape of osteoporosis.

Our study is the first population-based investigation into the risk of fragility fractures using the classification framework of OSTA, a widely utilized osteoporotic risk assessment instrument, in Thailand. We identified a markedly elevated risk of fragility fractures among patients classified as medium- and high-risk for osteoporosis using OSTA compared with those categorized as low risk. This observed trend persisted across both sexes. Our findings align closely with those of previous research, demonstrating a consistent association between OSTA-scored risk of osteoporosis and heightened susceptibility to bone fractures. Notably, our findings align with those reported by Chang et al.[19], wherein an elevated risk of osteoporosis assessed using OSTA was linked to an increased incidence of bone fractures in female patients with trauma. Elderly females consistently emerge as vulnerable demographic subgroups susceptible to fragility fractures. Irrespective of sex, the sixth decade of life stands out as a prevalent age group for such fractures. This observation is likely attributable to the decline in sex hormones levels experienced by both sexes during this life stage, coupled with sustained outdoor activities amid insufficient physical fitness, which predisposes individuals to fractures from minor trauma amid underlying comorbidities. Conversely, within the relatively younger age bracket of 40-60 years, aberrant BMI, characterized by either low or high values, emerged as a significant contributing factor to fragility fractures, accounting for 38.1% of fractures within this cohort. This underscores the notion that anomalous BMI, irrespective of age or sex, can promote fragility fractures, emphasizing the importance of BMI management in fracture prevention across diverse demographic groups.

According to OSTA, only a minority of patients (13.8%) are at high-risk of osteoporosis (OSTA < -4). However, the Poisson regression analysis in this study underscored a robust association between OSTA score and fragility fractures. Among the prevalent comorbidities, cardiovascular diseases were the most common. Hypertension is related to the occurrence of fragility fractures due to several interconnected mechanisms. Firstly, hypertension can lead to arterial stiffness and reduced blood flow, which can negatively impact bone health by diminishing the supply of essential nutrients and oxygen to the bone tissue. Additionally, high blood pressure is often associated with inflammation and oxidative stress, both of which can contribute to bone resorption and decrease bone mineral density, making bones more susceptible to fractures. Furthermore, antihypertensive medications, particularly diuretics, may affect calcium balance and bone metabolism. Lastly, individuals with hypertension may also have other comorbid conditions, such as diabetes or chronic kidney disease, which further exacerbate the risk of bone fragility and fractures[20]. Serum vitamin D3 levels have also been associated with fragility fractures[21], which highlights the need to comprehensively consider all risk factors, both for individuals with a history of fragility fractures and those who were recently afflicted, to mitigate the risk of recurrent fragility fractures in the same individual. Special attention should be directed towards factors with the potential to predict multiple fragility fractures, such as stroke and hypertension, while acknowledging factors that confer protection against fragility fractures, such as estrogen supplementation. This holistic approach to risk assessment and management is crucial to enhance fracture prevention strategies and promote bone health in affected individuals.

The study has several limitations. Firstly, there is potential for underdiagnosis and undertreatment of osteoporosis among individuals with dementia, as prior research indicates a reduced likelihood of osteoporosis treatment among those with severe dementia[22]. Secondly, the PHD lacks comprehensive information regarding smoking habits, alcohol consumption, socioeconomic status, and family history of systemic diseases, all of which could be pertinent risk factors for osteoporosis[23-24]. Thirdly, the methodological limitations inherent to a retrospective cohort study, including potential biases related to adjustments for confounding variables, may have affected the statistical robustness of the findings. Additionally, although the investigation suggests a lower risk of fragility fractures among patients receiving estrogen supplementation compared to those not undergoing any treatment, it is important to note that some instances of estrogen supplementation may have been administered locally rather than systemically, potentially attenuating the observed effects. The anonymized nature of the data within the PHD precludes access to clinical variables such as imaging and pathology results of the study patients. However, despite these limitations, data pertaining to weight, age, diagnosis of osteoporosis, and fragility fractures remain reliably documented in the database. Furthermore, all participants in the study hailed from the same geographic locale and sought medical attention at outpatient facilities within a single hospital, necessitating a multicenter investigation to afford a more comprehensive and robust analysis. At the study's onset, individuals with a history of fragility fractures in 2009 were excluded from the baseline assessment to identify newly diagnosed cases from 2009 to 2023, thereby enhancing the robustness of the findings. Lastly, the lack of detailed data on smoking, alcohol drinking, socioeconomic status, and family history, as well as the absence of longitudinal data, limits the ability to track the progression of both osteoporosis and dementia over time, underscoring the necessity for further research on these aspects[24].

CONCLUSION

The study provided an early detection method for fragility fractures. The outcomes derived from our comprehensive retrospective population-based investigation revealed an increased risk of fragility fractures among individuals within the Thai population in one institution classified as having medium and high risk of osteoporosis based on OSTA scores. Intriguingly, our analysis also underscores the notable association between estrogen supplementation and a lower risk of fragility fractures among these high-risk patients. This finding highlights the potential utility of estrogen supplementation as a preventive measure against fragility fractures in high-risk individuals, thus warranting further exploration and consideration in clinical practice.

CONFLICT OF INTEREST

Kasidid Lawongsa, Thitiphan Kanchanabul, and Jitrawee Tepakorn declare that they have no conflict of interest.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available in PubMed. For further correspondence, please contact kasidid.lawongsa@gmail.com

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