

Usefulness of the Singh Index in Predicting Hip Fracture Patterns in Older Adults: A Retrospective Study in A Second Level Hospital

Francisco Javier Ramos Monroy^{1*}, Ana Georgina Bautista Cortes², Rodrigo Fernando Duran Martínez³

¹Resident in Traumatology and Orthopedics, Regional General Hospital 1, Orizaba, Veracruz, Mexico, ORCID 0009-0009-3198-1335

²Non-Family Physician (Pediatrician) with a Doctorate in Education, Regional General Hospital 1, Orizaba, Veracruz, Mexico, ORCID 0009-0003-7090-7978

³Physician in Traumatology, Regional General Hospital No. 1, Orizaba, Veracruz, Mexico, ORCID 0009-0007-7361-8759

ABSTRACT

Introduction: The elderly population has increased in recent years, leading to a rise in age-related diseases. Hip fractures are particularly noteworthy, as over 90% of patients in the Traumatology and Orthopedics service are over 65 years old.

General Objective: To determine the usefulness of the Singh index in hip fractures in adults over 65 years of age at Regional General Hospital No. 1 Orizaba, and to identify related risk factors.

Methods: A retrospective, cross-sectional, descriptive, observational study was conducted. The study population consisted of 129 patients hospitalized in the Traumatology and Orthopedics Service between January 2023 and December 2024 at Regional General Hospital No. 1 in Orizaba, Veracruz.

Results: Of the 129 patients, 63.16% (84 patients) presented with transtrochanteric fractures, with a higher incidence in women (64 cases, 64.6%) and in patients over 75 years of age (94 patients, 72.86%). A statistically significant correlation was found between the Singh index and the anatomical location of the fracture ($r = -0.39$, $p < 0.001$), suggesting that greater trabecular bone loss is associated with intracapsular fractures.

Conclusions: The Singh index showed a statistically significant association with hip fracture type in older adults, and therefore can be considered a useful tool as an indirect estimator of bone quality in resource-limited clinical settings. However, its value should be interpreted with caution due to its methodological limitations. Level of evidence: III (retrospective analytical observational study).

Keywords: Hip fracture, Risk factors, Singh index, Orthogeriatrics

ARTICLE DETAILS

Published On:
08 October 2026

Available on:
<https://ijmscrs.com>

INTRODUCTION

At Regional General Hospital No. 1 in Orizaba, there is a growing incidence of chronic diseases, which not only complicate medical treatments but also increase the risk of fractures. This situation highlights the need to assess the control status of these comorbidities in order to optimize resources and improve care. (18)

Several studies support the importance of addressing comorbidities in patients with hip fractures. For example, a study published in the *Journal of Bone and Mineral Research* revealed that the presence of diabetes significantly

increases the risk of hip fractures in older adults, highlighting the importance of assessing and managing this condition in orthopedic patients (2).

Demographic changes over the past few decades have led to an increase in the number of older adults. This increase has been accompanied by a higher prevalence of chronic noncommunicable diseases such as osteoporosis and its consequences, including hip fractures. Frail older adults are often inherently at greater risk for adverse events such as falls and fragility fractures. There is a gap in treatment for patients with osteoporosis and a high risk of hip fracture. This

Usefulness of the Singh Index in Predicting Hip Fracture Patterns in Older Adults: A Retrospective Study in A Second Level Hospital

situation mirrors what is happening in other countries, presenting an opportunity to reduce the risk of future fractures. In Mexico, one in four adults has osteopenia or osteoporosis, and at the end of the last century, an average of 100 hip fractures per day was estimated. By 2050, the global rate of hip fractures is expected to rise to approximately 21 million per year. Compared to developed countries, Mexico still lags behind to some extent. There is still no national registry, and efforts to improve care and research on hip fractures remain isolated. Most studies conducted in Mexico City at orthopedic hospitals have focused exclusively on pertrochanteric fractures, and one has focused on intracapsular fractures; only one study has included all three main types of fractures, with a frequency of 36% intracapsular, 56% pertrochanteric, and 8% subtrochanteric. (3)

The Singh index, which describes trabecular patterns in the proximal femur, has been used as a predictor of hip fractures and as an indicator of osteopenia. Evidence suggests that its contribution to the assessment of hip fracture risk lies in its description of the structural properties of the femur. (4)

Hip fractures, in particular, have emerged as a public health problem, especially among older adults, resulting in substantial healthcare costs and a significant impact on quality of life. Identifying risk factors is crucial for reducing these injuries and their consequences (5).

Given the above, the objective of this study is to examine the utility of the Singh index in hip fractures among older adults, as well as the risk factors that contribute to these fractures. This study was motivated by the high incidence of hip fractures in older adults, which poses a significant challenge to the healthcare system and requires effective prevention and management interventions. The objective is to assess the utility of the Singh index in hip fractures among adults aged 65 and older at Regional General Hospital No. 1

MATERIALS AND METHODS

Information will be obtained by reviewing medical records using a questionnaire designed to gather data from the medical history. Data collection was conducted after authorization was granted; subsequently, a database was created in an Excel spreadsheet using the collected data. The entire population of patients with hip fractures was included, comprising 100% of those who met the criteria during the period from 2023 to 2024, resulting in a sample of 129 patients.

Subsequently, statistical analysis was performed using SPSS, including descriptive statistics to describe frequencies, percentages, and means, as well as inferential statistics using

Pearson's correlation to determine the association between the Singh Index and hip fractures.

The Kolmogorov-Smirnov test was performed with respect to age and the Singh Index.

Study design: observational, retrospective, cross-sectional, descriptive. The study will be conducted by analyzing patient records from 2023 and 2024 of individuals over 65 years of age diagnosed with a hip fracture, specifically those enrolled at Regional General Hospital No. 1 in Orizaba

Inclusion Criteria

- Age 65 or older
- Diagnosis of a hip fracture
- Admitted to Orizaba Regional General Hospital No. 1

Exclusion Criteria

- Genetic condition that directly affects bone metabolism
- Patients with cancer
- Patients with chronic kidney disease
- Medical records lacking a certain percentage of information

Elimination Criteria

- Incomplete medical records

General Objective

To determine the usefulness of the Singh index and other factors in hip fractures among adults over 65 years of age at Regional General Hospital No. 1 in Orizaba, and related risk factors.

Specific objectives:

1. Classify the most common type of hip fracture in adults over 65 years of age
2. To identify the relationship between age and the type of hip fractures in adults over 65 years of age.
3. To determine the association between the fracture site and gender. 1
4. To determine the association between smoking and the anatomical site of hip fractures.
5. To determine the frequency of medication use in patients over 65 years of age with hip fractures.
6. To correlate the Singh index in adults over 65 years of age with the type of hip fracture.
7. To determine the frequency of hip fractures in adults over 65 years of age with a history of a previous fracture

RESULTS

The most common types of hip fractures in patients over 65 years of age were classified. It was observed that the trans-trochanteric fracture was the most common, with 84 patients (63.16%), followed by the femoral neck fracture with 40 cases (30.08%) and the subtrochanteric fracture with 5 patients (3.76%). No cases of femoral head fractures were recorded in the study population (Figure 1).

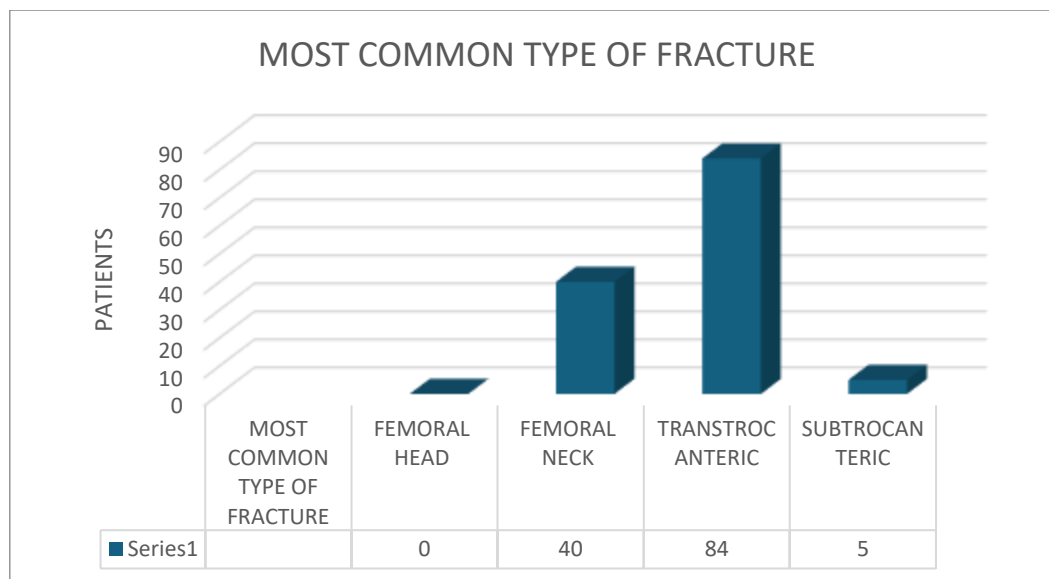


Figure 1. Distribution of hip fracture types in individuals over 65 years of age.

The trans-trochanteric fracture had the highest incidence in this age group (n = 129 patients).

When analyzed by age group, it was observed that the highest frequency of fractures was concentrated among patients over 75 years of age, with 94 cases (72.86%), of which 60 (63.8%) were trans-trochanteric, 30 (31.91%) were femoral neck fractures, and 4 (4.25%) were subtrochanteric fractures.

In the 65- to 75-year-old group, 35 fractures (27.13%) were identified, distributed as follows: 24 (68.57%) were trans-trochanteric, 10 (28.57%) were femoral neck fractures, and 1 (2.85%) was subtrochanteric.

The results suggest that the incidence of fractures increases with age, possibly in relation to decreased bone density and other age-related changes (Figure 2).

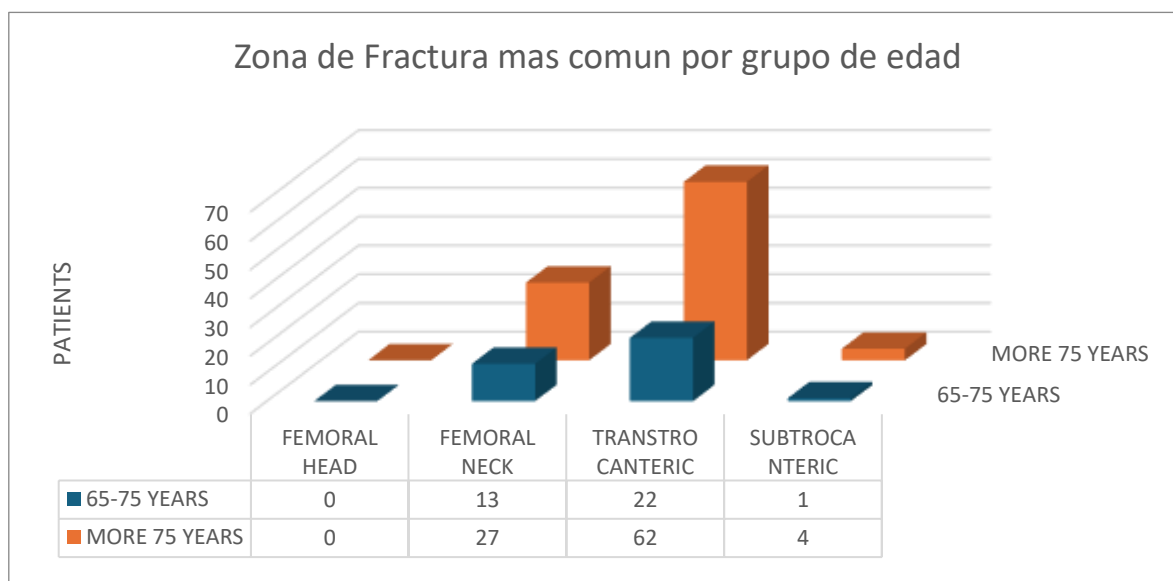


Figure 2. Relationship between age and type of hip fracture.

Among men, the transtrochanteric fracture was the most common, with 20 cases (58.8%), followed by the femoral neck fracture with 12 cases (35.2%) and one case of subtrochanteric fracture (2.9%). Among women, trans-trochanteric fractures also predominated, with 64 cases (64.6%), followed by femoral neck fractures with 28 cases

(28.2%) and subtrochanteric fractures with 4 cases (4%). No femoral head fractures were reported in either group. This difference could be related to factors such as the higher prevalence of osteoporosis in women and differences in biomechanics and bone density between the sexes (Figure 3).

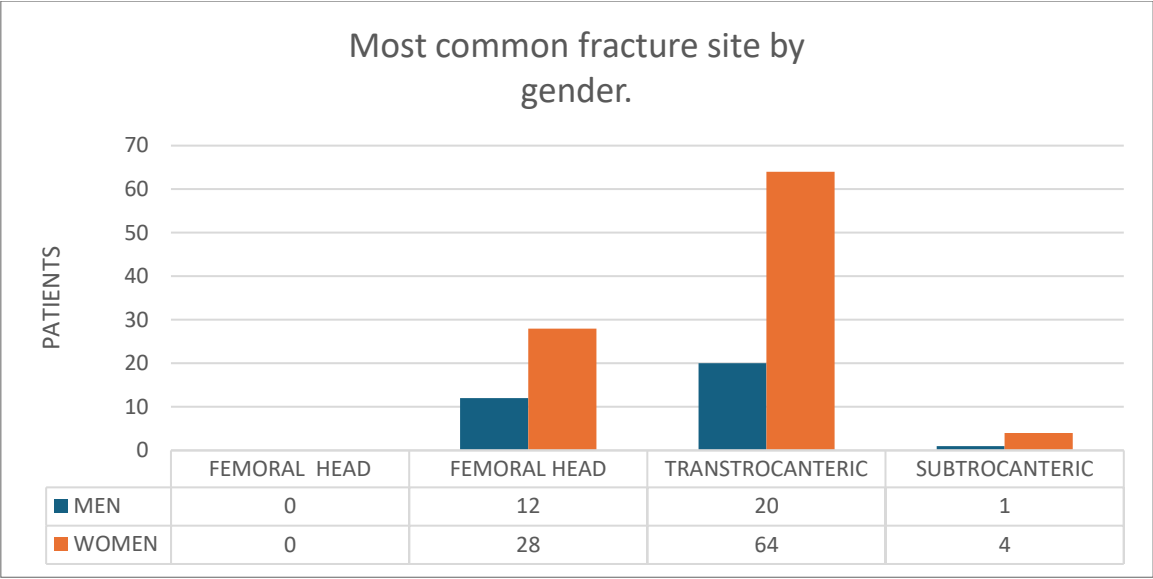


Figure 3. Distribution of fractures by sex.

An analysis of medication use revealed that proton pump inhibitors (PPIs) were the most commonly used, with 11 patients, followed by diuretics (10 patients), NSAIDs (7 patients), thyroid replacement therapy (6 patients), bisphosphonates and steroids (3 patients each), and calcium and vitamin D supplements (1 patient each). The high use of

PPIs and diuretics could be associated with an increased risk of fracture due to their negative impact on calcium absorption and bone health. Noteworthy is the low use of bisphosphonates, calcium, and vitamin D, despite their protective role in preventing osteoporosis (Figure 4).

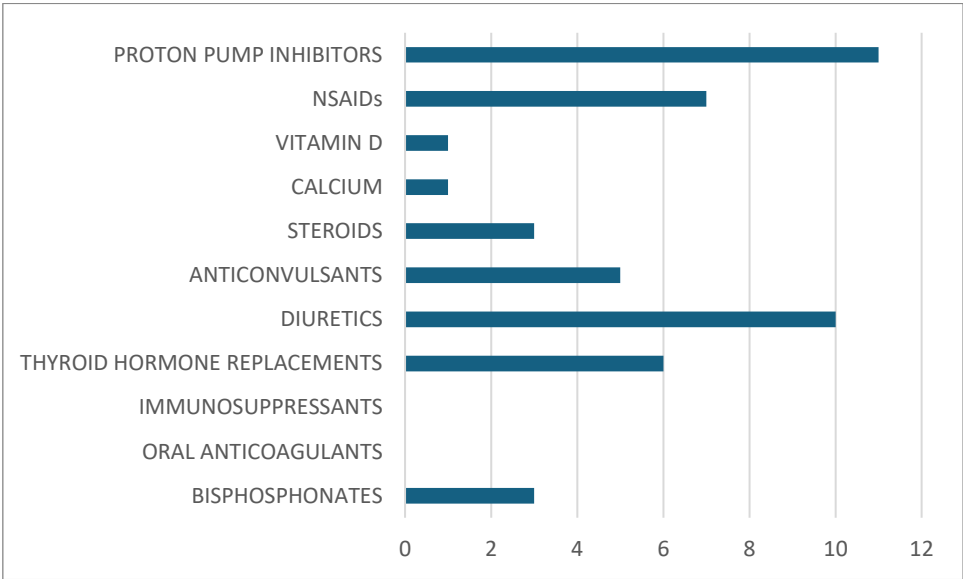


Figure 4. Medications taken by patients with hip fractures.

It was found that 33.3% (43 patients) had a history of a previous fracture, while 66.7% (86 patients) did not. This finding highlights the importance of implementing preventive

strategies, such as timely treatment of osteoporosis and fall prevention, in this population (Figure 5).

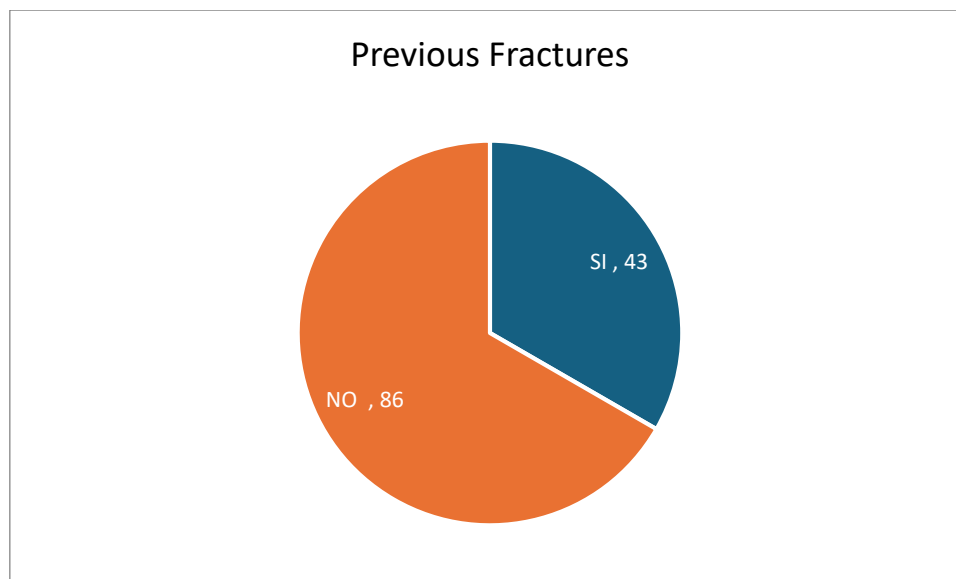


Figure 5. Presence of a Previous Fracture in Patients with a Hip Fracture.

Comorbidities were also evaluated, with systemic hypertension and diabetes mellitus being the most common. Systemic hypertension was present in 82 patients (63.6%), and diabetes mellitus in 49 patients (38.0%). Seven patients with dementia (5.4%), seven with chronic kidney disease (5.4%), six with hypothyroidism (4.7%), as well as one patient with osteoporosis (0.8%) and one case of anemia

(0.8%) were also identified. No patients with hyperthyroidism were reported.

Although these conditions are not directly related to the occurrence of fractures, they can influence the patient's clinical course, increasing the risk of complications such as infections or delayed bone healing, which directly impacts surgical and postoperative management (Figure 6)

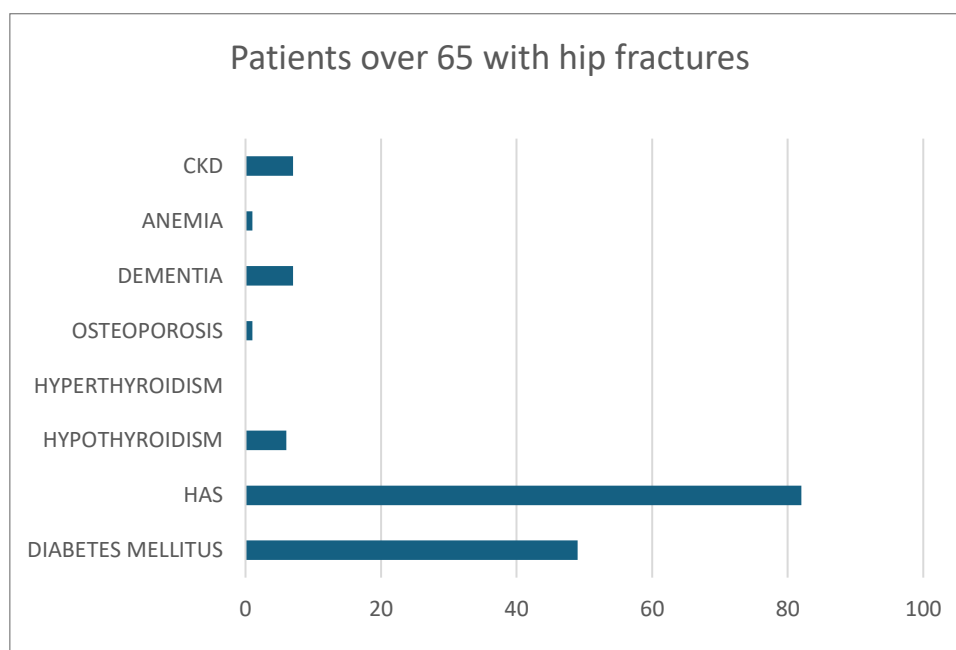


Figure 6. Comorbidities in patients over 65 years of age with hip fractures.

When performing a Pearson correlation analysis between smoking and the location of the hip fracture. The correlation coefficient was $r = -0.042$ ($p = 0.639$), indicating a very weak

negative correlation with no clinical or statistical significance. This suggests that tobacco use has no direct effect on the anatomical location of the fracture. (Table 1)

Usefulness of the Singh Index in Predicting Hip Fracture Patterns in Older Adults: A Retrospective Study in A Second Level Hospital

Table 1. Smoking

		FX	TABAQUISMO
FX	CORRELACION PEARSON	1.000	-0.042
	SIG. (BILATERAL)	0.042	-0.032
	N	129.000	0.422
SMOKING	CORRELACION PEARSON	-0.021	0.000
	N	1.000	1.000

Regarding the distribution by smoking status, 28 femoral neck fractures were observed in nonsmokers (21.7%) and 14 in smokers (10.85%); 65 transtrochanteric fractures in nonsmokers (50.38%) and 18 in smokers (13.95%); and 4

subtrochanteric fractures in nonsmokers (3.1%) compared with 1 in smokers (0.77%). Although smoking is a risk factor, in this sample it did not appear to significantly influence the anatomical location of the fracture (Figure 7).

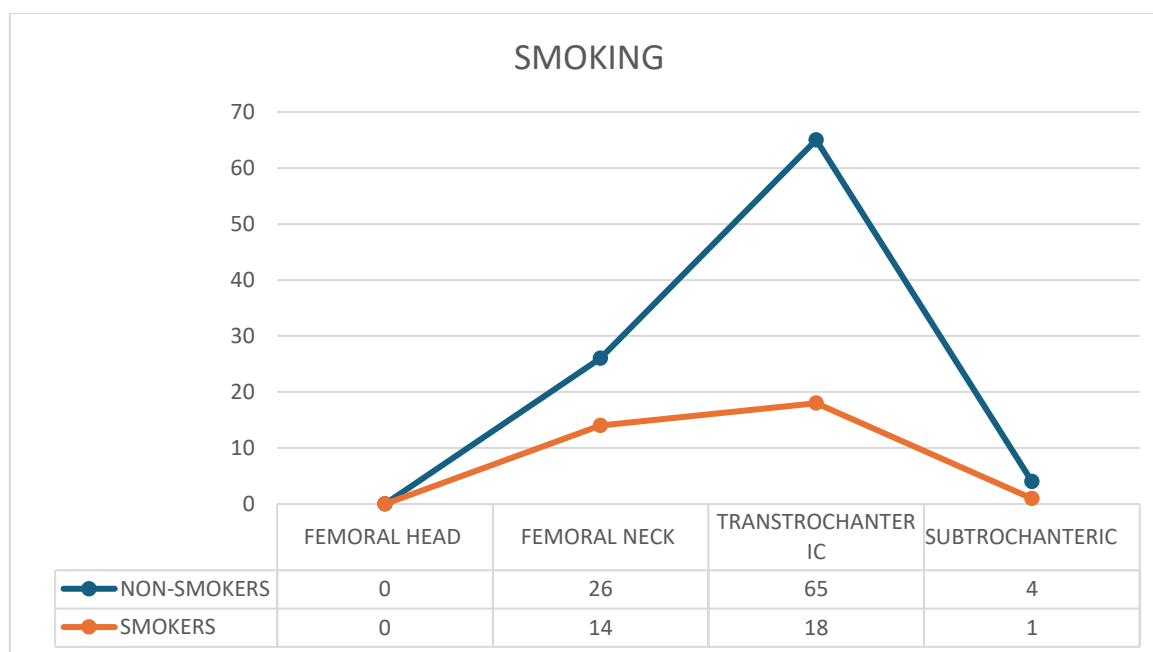


Figure 7. Relationship between smoking and the anatomical location of hip fractures.

In the analysis of the Singh Index and its relationship with the anatomical site of the fracture, a moderate and statistically significant negative correlation was found ($r = -0.39$; $p < 0.001$), suggesting that a lower Singh Index is associated with

a higher risk of femoral neck fractures. Significant reverse associations were observed in the Pearson analyses. Conversely, patients with a higher Singh index tended to present with transtrochanteric fractures. (Table 2)

Table 2. Singh Index

TYPE OF ANALYSIS	MEASURE	VALOR	ERROR ESTANDAR	ESTADISTICO (P)
NOMINAL VS NOMINAL	CONTINGENCY COEFFICIENT	0.465	0.26	0.033
INTERVAL VS INTERVAL	PEARSON'S CORRELATION	-0.261	-3.061	-3.049
ORDINAL VS ORDINAL	SPEARMAN'S CORRELATION	-0.399	-4.901	<0.001

Regarding the distribution by grade on the Singh Index, femoral neck fractures were predominantly classified as Grade III (18 cases; 48.6%) and Grade II (15 cases; 40.5%), with a lower frequency in Grade IV (6 cases; 16.2%). No

cases were observed in grades I, V, or VI; as for transtrochanteric fractures, a predominance was observed in grades III (37 cases; 44.04%) and IV (36 cases; 42.85%), with fewer cases in grade II (4), grade V (6), and grade VI (1); for

Usefulness of the Singh Index in Predicting Hip Fracture Patterns in Older Adults: A Retrospective Study in A Second Level Hospital

subtrochanteric fractures: they were distributed between grade III (2 cases) and grade IV (3 cases), with no cases in other grades. Grades III and IV of the Singh index were the

most frequent, with the trans-trochanteric fracture standing out as the most common (Figure 8).

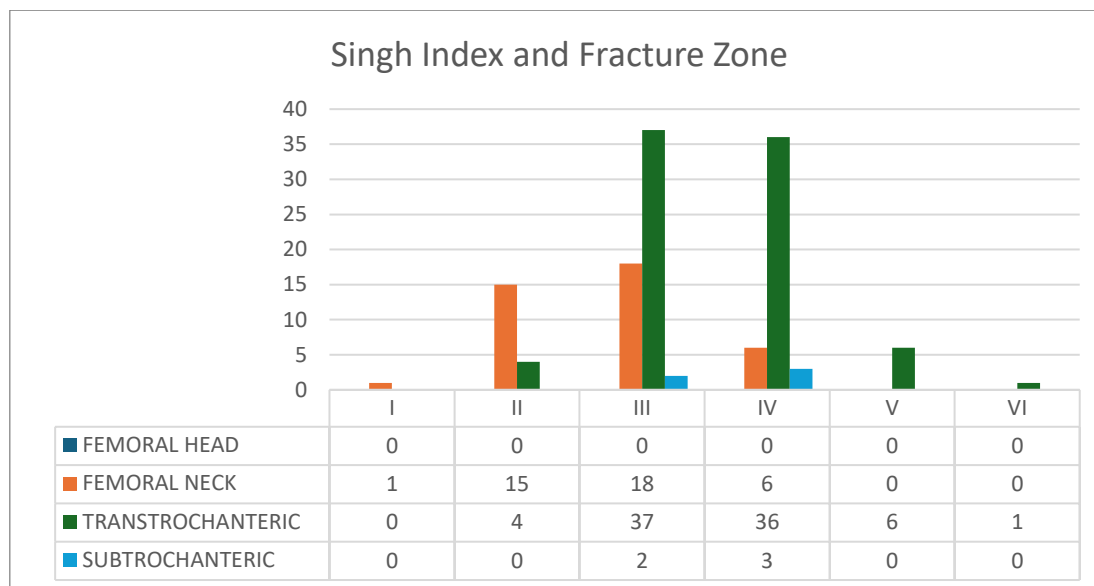


Figure 8. Relationship between the Singh index and the anatomical site of the fracture.

The Kolmogorov-Smirnov test was performed for age and the Singh index. The analysis yielded a p-value of .006 ($p < .001$) for the one-sample Kolmogorov-Smirnov normality test;

therefore, the alternative hypothesis is accepted and the null hypothesis is rejected. (TABLE 3)

Table 3. Kolmogorov-Smirnov Test

Table 3. Kolmogorov-Smirnov Test for a Single Sample

		edad	singh
N		129	129
Normal parameters ,b	Mean	80.87	3.30
	Standard deviation	7.779	.835
Maximum outliers	Absolute	.095	.238
	Positive	.083	.238
	Negative	-.095	-.204
Test statistic		.095	.238
Significance (two-tailed)c		.006	<.001
Monte Carlo significance (two-Significance		.006	<.001
tailed)d	confidence interval 99%		
	Lower limit	.004	.000
	Upper limit	.008	.000

a. The test distribution is normal..

b. Calculated from the data

c. Lilliefors significance correction.

d. The Lilliefors method based on 10,000 Monte Carlo samples with a starting seed of 2,000,000.

DISCUSSION

This study analyzed the use of the SIGH index as well as the risk factors associated with different types of hip fractures in adults over 65 years of age treated at Regional General Hospital No. 1 in Orizaba. The results are consistent with those reported in the international literature and also highlight specific areas for improvement in the local context.

Hip fractures represent one of the leading causes of morbidity and mortality in older adults. In this study, clinical and epidemiological patterns were identified that allow for a better understanding of these fractures and their associated factors, particularly the predictive value of the Singh Index as a radiological tool for estimating bone fragility associated with the fracture site.

Usefulness of the Singh Index in Predicting Hip Fracture Patterns in Older Adults: A Retrospective Study in A Second Level Hospital

A high frequency of transtrochanteric fractures was observed, accounting for 63.16% of all cases. This finding is consistent with previous studies indicating that the frequency of extracapsular fractures increases with advancing age, attributable to greater bone fragility and loss of trabecular architecture (6). The age distribution showed a higher incidence among those over 75 years of age (72.86%), reinforcing the notion that aging represents a significant biomechanical risk.

With regard to gender, a higher proportion of women was observed, with women accounting for a larger share across all fracture types. This trend has been widely documented and is associated with accelerated postmenopausal bone mass loss and the high prevalence of osteoporosis in older women (7). Tobacco use did not show a statistically significant association with the anatomical location of the fracture. Although tobacco is recognized as a factor contributing to decreased bone mineral density, these results suggest that its influence may be more relevant to overall bone quality than to predicting a specific anatomical site of fracture (8).

One of the most important and clinically useful findings was the relationship between the Singh index and the location of the fracture. This index, which assesses trabecular loss in the proximal femur on plain radiographs, showed a clear association: lower Singh index grades (II and III) were associated with a higher prevalence of femoral neck fractures, whereas higher index grades (III and IV) were associated with a higher prevalence of transtrochanteric fractures. This pattern suggests that profound trabecular loss—characteristic of low grades on the Singh index—has a more critical impact on the femoral neck, an intracapsular region that is highly dependent on trabecular integrity to withstand loads. In contrast, intermediate or high Singh index grades reflect a bone architecture that is still competent but weakened, which predisposes to fractures in areas of structural transition, such as the transtrochanteric region (9).

This finding has direct clinical implications: the Singh index, as an accessible, rapid, and low-cost tool, can help physicians anticipate the type of fracture that might occur following a minor trauma. Furthermore, it can guide decisions regarding primary or secondary prevention in patients with radiographic findings suggestive of severe osteopenia. In settings where bone densitometry is not always available—as is often the case in secondary care—the Singh index can be a useful resource. It is worth noting that this correlation was statistically significant, with a negative correlation coefficient ($r = -0.39$, $p < 0.001$), which reinforces the usefulness of the Singh index not only as a marker of fragility but also as an anatomical predictor of fracture site (10).

In conclusion, our findings reinforce the usefulness of the Singh index as a predictive tool for fracture type and highlight the importance of establishing prevention programs and comprehensive care for older adults with risk factors for hip fractures. Early identification of patients with advanced

osteopenia and timely management of their comorbidities could reduce both the incidence and the complications associated with this type of injury.

Regarding previous fractures, it is noteworthy that 33% of patients had a history of a previous fracture, which underscores the need to establish secondary prevention programs in this population due to their increased risk of sustaining a hip fracture. The presence of comorbidities such as hypertension, diabetes mellitus, and heart disease—which were also prevalent in this study—should be considered not only as risk factors for fracture but also as factors that negatively influence postoperative recovery and the patient's overall prognosis (35).

This study reaffirms the importance of a comprehensive and preventive approach for older adults at risk of hip fracture, taking into account biomechanical, pharmacological, nutritional, and social factors. At the institutional level, our findings may contribute to the design of specific plans, such as those established internationally under the terms “Hip Code,” “orthogeriatrics,” and “comprehensive multidisciplinary care.”

External validity: The results apply primarily to the population treated at Regional General Hospital No. 1 in Orizaba; generalization to other regions or contexts should be done with caution due to differences in demographics and access to health services.

Funding and Support: This study received no external funding or additional institutional support.

Limitations

The study has some limitations that should be considered when interpreting the results. First, it is a retrospective study based on a review of clinical records, which implies information biases arising from incomplete or heterogeneous records. Furthermore, the sampling was non-probabilistic and based on convenience, limited to a single hospital, which may limit the generalizability of the results to other populations.

The sample size also limits the ability to perform multivariate statistical analyses that would allow for the control of potential confounding variables.

Finally, the Singh index, although widely used as a radiological tool to estimate bone quality, has been questioned in recent literature due to its interobserver variability and its limited correlation with bone densitometry. The Singh index classification was performed by reviewing plain radiographs by two evaluators trained in traumatology and orthopedics. In cases of disagreement, a consensus was reached.

Interobserver agreement was not assessed using the Kappa coefficient.

CONCLUSIONS

This study evaluated the utility of the Singh index in predicting hip fracture patterns among older adults at

Usefulness of the Singh Index in Predicting Hip Fracture Patterns in Older Adults: A Retrospective Study in A Second Level Hospital

Regional General Hospital No. 1 in Orizaba. The findings are consistent with the international literature but also reveal epidemiological characteristics of our population that should be considered in local clinical practice to optimize prevention, diagnosis, and treatment.

A high incidence of trans-trochanteric fractures was observed, predominantly in women over 75 years of age, which is related to bone fragility associated with aging and postmenopausal hormonal changes. Despite the availability of preventive therapeutic strategies, we observed low use of supplements such as calcium, vitamin D, and bisphosphonates, along with high consumption of medications that can negatively affect bone health, such as proton pump inhibitors (PPIs) and diuretics.

One of the most significant findings was the statistically significant correlation between the Singh index and fracture location. This radiological index, based on the evaluation of the trabecular architecture of the proximal femur, showed a moderate inverse relationship with fracture type, making it a diagnostic tool of great clinical utility. Its low cost, availability, and ease of use make it a viable alternative for assessing bone fragility in settings where bone densitometry is not available, allowing for the prediction of fracture patterns following low-impact trauma.

These results reinforce the need to adopt a comprehensive and multidisciplinary approach to the care of older adults at risk for hip fractures. Timely detection of risk factors, appropriate medical and nutritional intervention, and the implementation of institutional protocols such as the "Hip Code" or orthogeriatric programs are key strategies for improving functional outcomes, reducing complications, and enhancing quality of life in this vulnerable population.

REFERENCES

- I. Buzkova P, Cauley JA, Fink HA, Robbins JA, Mukamal KJ, Barzilay JI. Age- related factors associated with the risk of hip fracture. *Endocr Pract.* 2023 Jun;29(6):478-83. doi: 10.1016/j.eprac.2023.03.001. Epub 2023 Mar 7. PMID: 36889582; PMCID: PMC10258141.
- II. Palui R, Pramanik S, Mondal S, Ray S. Critical review of bone health, fracture risk and management of bone fragility in diabetes mellitus. *World J Diabetes.* 2021 Jun 15;12(6):706-29. doi: 10.4239/wjd.v12.i6.706. PMID: 34168723; PMCID: PMC8192255.
- III. Dzul-Hernández J, Argáez-Manzanero A, García-Durán A, Alejos-Gómez R, Méndez-Domínguez N. Fracturas de cadera en adultos mayores del Hospital General Agustín O'horán entre 2015 y 2019. *Rev Cubana Ortop Traumatol* 2021 Jun [citado 2024 Ene 10];35(1):e284. Disponible en: http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S0864-215X2021000100003&lng=es
- IV. Flores LM. Correlación entre el índice córtico diafisario femoral y la escala de Singh como método predictivo para fracturas de cadera [Tesis]. Veracruz: Universidad Veracruzana, IMSS; 2020.
- V. McDonough CM, Whitney SL, Alghadir A, Beauchamp MK, Binder EF, et al. Physical therapy management of older adults with hip fracture. *J Orthop SportsPhys Ther.* 2021 Feb;51(2):CPG1-CPG81. doi: 10.2519/jospt.2021.0301.
- VI. Revista Española de Cirugía Ortopédica y Traumatología. Factores de riesgo en fracturas de cadera trocantéricas y de cuello femoral [Internet]. Disponible en: <https://www.elsevier.es/es-revista-revista-espanola-cirugia-ortopedica-traumatologia-129-avance-factores-riesgo-fracturas-cadera-trocantéricas-S1888441517301327>
- VII. Acta Médica. Factores de riesgo en fracturas de cadera trocantéricas y de cuello femoral [Internet]. Disponible en: <https://www.actuamed.com.mx/contenido-publico/factores-de-riesgo-en-fracturas-de-cadera-trocantéricas-y-de-cuello-femoral>
- VIII. Revista Sanitaria de Investigación. Fracturas de cadera y su relación con osteoporosis medida mediante el índice de Singh en pacientes adultos mayores [Internet]. Disponible en: <https://revistasanitariadeinvestigacion.com/fracturas-de-cadera-y-su-relacion-con-osteoporosis-medida-mediante-el-indice-de-singh-en-pacientes-adultos-mayores/>
- IX. Singh M, Nagrath AR, Maini PS. Changes in trabecular pattern of the upper end of the femur as an index of osteoporosis. *J Bone Joint Surg Am.* 1970;52(3):457-67.
- X. Koot VC, Kesselaer SM, Clevers GJ, de Hooge P, Weits T, van der Werken C. Evaluation of the Singh index for measuring osteoporosis. *J Bone Joint Surg Br.* 1996;78(5):831
- XI. Secretaría de Salud. CENETEC; 2018.
- XII. Veronese N, et al. Osteoporosis Int. 2023;34(1):1-12.
- XIII. Bhandari M, Swiontkowski MF. *N Engl J Med.* 2017;377(21):2053-2062.
- XIV. Schipper IB, et al. *J Orthop Trauma.* 2020;34(2):e52-7.
- XV. Kanis JA, et al. *Osteoporosis Int.* 2019;30(1):3-44.
- XVI. Gullberg B, et al. *Osteoporosis Int.* 1997;7(5):407-413