Factors Associated with Recurrence of Vertebral Fractures after Vertebroplasty in Older Adults

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ABSTRACT

Introduction: Osteoporotic vertebral fractures are a common cause of morbidity in older adults. Identifying risk factors for refracture is crucial to prevent complications. **Objective:** To evaluate clinical and imaging variables associated with vertebral refracture after vertebroplasty. **Materials and Methods:** An observational study was conducted including a consecutive series of patients who underwent vertebral cementation between 2017 and 2024. The cohort was divided into two groups according to the presence (refracture group, RG) or absence (non-refracture group, NRG) of refracture within two years, defined as a new fracture in either of the two vertebrae adjacent above or below the treated level. Clinical, surgical, and imaging variables were compared. Bone density was assessed using the mean Hounsfield units (HU) of the adjacent vertebrae. **Results:** A total of 118 patients were included (RG: 80; NRG: 38). No significant differences were observed in age, sex, or comorbidities between groups. A history of osteoporotic fracture was more frequent in the RG (42.67% vs. 21.62%, p = 0.03). The number of fractured vertebrae was higher in the RG (2 vs. 1, p = 0.005). Bone density below the treated vertebra was significantly lower in the RG (70 HU vs. 95.69 HU, p = 0.001). In multivariate analysis, lower bone density was the only independent predictor of refracture (OR 0.98; 95%CI 0.96–0.99). The median refracture-free interval was 12 months. **Conclusion:** Lower bone density in the vertebrae adjacent below the treated level is associated with a higher risk of vertebral refracture.

Keywords: Osteoporosis; vertebral fractures; Hounsfield units; vertebroplasty; bone density; kyphoplasty.
Level of Evidence: III

Factores asociados a la recurrencia de las fracturas vertebrales tras una vertebroplastia en el adulto mayor

RESUMEN

Introducción: Las fracturas vertebrales osteoporóticas constituyen una causa frecuente de morbilidad en adultos mayores. Identificar factores de riesgo de refractura resulta crucial para prevenir complicaciones. **Objetivo:** Evaluar variables clínicas e imagenológicas asociadas con la refractura vertebral. **Materiales y Métodos:** Estudio observacional de una serie consecutiva de pacientes sometidos a cementación entre 2017 y 2024. La cohorte se dividió en 2 grupos: con refractura (CF) y sin refractura (SF) dentro de los 2 años, definida como nueva fractura en las 2 vértebras adyacentes por encima o por debajo del nivel tratado. Se compararon variables clínicas, quirúrgicas e imagenológicas. La densidad ósea se midió usando el promedio de unidades Hounsfield (UH) en las vértebras adyacentes. **Resultados:** Se incluyó a 118 pacientes (CF 80, SF 38). No se observaron diferencias significativas en la edad, el sexo ni las comorbilidades. El antecedente de fractura osteoporótica fue más frecuente en el grupo CF (42,67% vs. 21,62%, p = 0,03). El número de vértebras fracturadas fue mayor en el grupo CF (2 vs. 1, p = 0,005). La densidad ósea debajo de la vértebra tratada fue significativamente menor en el grupo CF (70 UH vs. 95,69 UH, p = 0,001). En el análisis multivariado, la densidad ósea inferior fue el único factor predictivo independiente (OR 0,98; IC95% 0,96-0,99). La mediana de tiempo sin refractura fue de 12 meses. **Conclusión:** Una menor densidad ósea en las vértebras adyacentes inferiores al nivel tratado se asocia con un mayor riesgo de refractura.

Palabras clave: Osteoporosis; fracturas vertebrales; unidad Hounsfield; vertebroplastia; densidad ósea; cifoplastia.
Nivel de Evidencia: III

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INTRODUCTION

Osteoporotic vertebral fractures are common in older adults and are associated with pain, loss of function, and an increased risk of subsequent compression fractures. Vertebroplasty is a widely used technique to relieve pain and stabilize these fractures; however, refractures represent a relevant complication and have an impact on morbidity, mortality, and length of hospital stay.[1]

The risk of refracture has been attributed to several factors, including age, sex, bone density, and clinical history.[2] Bone density can be assessed using traditional methods such as dual-energy X-ray absorptiometry; however, recent studies have proposed the use of Hounsfield units (HU), obtained from computed tomography (CT) scans, as a useful tool for estimating local vertebral bone density.[3]

The aim of this study was to identify clinical, surgical, and imaging-related factors associated with vertebral refracture after vertebroplasty, with special emphasis on the analysis of bone density measured in HU in the vertebrae adjacent to the treated level.

MATERIALS AND METHODS

A retrospective observational study was conducted including patients who underwent vertebroplasty or kyphoplasty for an osteoporotic vertebral fracture between January 2017 and February 2024 at our hospital. Patients aged 50 years or older were included if they presented with low back pain associated with a vertebral fracture resulting from low-energy trauma, had evidence of a recent fracture on computed tomography, were initially treated with vertebroplasty or kyphoplasty, had complete imaging studies (computed tomography and magnetic resonance imaging), and had a minimum clinical follow-up of 12 months.

Patients with fractures caused by high-energy trauma, initial treatment with instrumented fixation, previous spinal surgery, burst fractures, neurological deficits, pathological fractures (tumoral or infectious), incomplete imaging studies, or loss to clinical follow-up were excluded.

Demographic and clinical variables were obtained from electronic medical records. The following data were recorded: age, body mass index, history of diabetes, smoking status, chronic corticosteroid use, bisphosphonate therapy, and history of vertebral fractures. Surgical parameters were also documented, including the location and number of fractured vertebrae, type of procedure performed (vertebroplasty or kyphoplasty), volume of cement injected, cement distribution pattern, presence of cement leakage (including intradiscal leakage), occurrence of refracture, and time elapsed until refracture.

All patients underwent a preoperative CT scan of the thoracic or lumbar spine using a 320-detector CT scanner (Toshiba Aquilion One). Trabecular bone density was assessed in HU using the PACS system. For each patient, two vertebrae above and two below the fractured level were selected. In each vertebra, an axial slice at the mid-vertebral body level was identified and correlated with the sagittal view. An oval region of interest (ROI) centered on the cancellous bone was placed, and the system automatically calculated the trabecular attenuation value. For analysis, the mean HU value of the two upper adjacent vertebrae and the mean HU value of the two lower adjacent vertebrae were used.

Percutaneous vertebroplasty was performed under general anesthesia and sterile conditions in the catheterization laboratory (Azurion 3 M12, Philips). With the patient in the prone position, the affected vertebra was accessed via a unilateral or bilateral transpedicular approach, depending on the case, under fluoroscopic guidance using anteroposterior and lateral views. Polymethyl methacrylate cement was injected slowly using a mechanical delivery system. At the end of the procedure, patients remained under observation for 4 hours and were discharged on the same day if no complications occurred.

Statistical Analysis

Categorical variables were analyzed using the χ^2 test, and continuous variables using Student's *t*-test. Variables that were statistically significant in the bivariate analysis were included in a multivariable logistic regression model to identify independent risk factors for refracture. Receiver operating characteristic (ROC) curve analysis was performed to assess the discriminatory ability of diagnostic variables and predictive models and to determine the optimal cutoff point for the mean HU value below the fractured vertebra, with the aim of facilitating its clinical application. Time free from refracture was estimated using Kaplan–Meier survival curves. A p value <0.05 was considered statistically significant.

RESULTS

The analysis included 476 patients, of whom 118 met the inclusion criteria. Eighty patients sustained refractures (RG), while 38 did not present new fractures (NRG). The proportion of women was similar between groups: 65 patients (81.25%) in the RG and 29 patients (78.38%) in the NRG ($p = 0.72$). Median age was 77 years (range 40–91) in the RG and 79 years (range 56–95) in the NRG ($p = 0.44$).

Regarding comorbidities, obesity was present in 3 patients (3.75%) in the RG and 3 patients (8.11%) in the NRG ($p = 0.32$). Twenty-four patients (30%) in the RG and 9 patients (24.32%) in the NRG were smokers ($p = 0.53$). Cardiovascular comorbidities were reported in 27 patients (33.75%) in the RG and 10 patients (27.03%) in the NRG ($p = 0.47$). Corticosteroid therapy was used by 9 patients (11.25%) in the RG and 2 patients (5.56%) in the NRG ($p = 0.33$), while bisphosphonate therapy was reported in 18 patients (22.5%) and 4 patients (11.11%), respectively ($p = 0.15$).

The number of fractured vertebrae was higher in RG patients (median 2, range 1–7) compared with NRG patients (median 1, range 1–4) ($p = 0.005$). Mean HU values above the fracture were significantly lower in the RG (mean 69.52; range 10–230) than in the NRG (mean 88.96; range 24.5–189.5) ($p = 0.01$). Similarly, mean HU values below the fracture were significantly lower in the RG (mean 70.00; range 14–135) compared with the NRG (mean 95.69; range 37.5–191.5) ($p = 0.001$).

Intraoperatively, trabecular cement distribution was similar between groups: 17 patients (21.25%) in the RG and 9 patients (24.32%) in the NRG ($p = 0.71$). Cement leakage into the adjacent intervertebral disc was observed in 11 patients (13.75%) in the RG and 5 patients (13.51%) in the NRG ($p = 0.97$).

In the multivariable logistic regression analysis, the mean HU value below the fracture was identified as an independent risk factor for refracture (odds ratio [OR] 0.98; 95% confidence interval [CI] 0.96–0.99). In contrast, the mean HU value above the fracture was not significantly associated with refracture (OR 1.00; 95% CI 0.98–1.02). A history of vertebral fracture (OR 1.59; 95% CI 0.59–4.28) and the number of fractured vertebrae (OR 1.47; 95% CI 0.91–2.35) were also not identified as significant risk factors. ROC curve analysis identified an optimal cutoff value of 87.75 HU for the mean HU value below the fracture, with a sensitivity of 75% and a specificity of 58.3%, according to Youden's index (Figure 1).

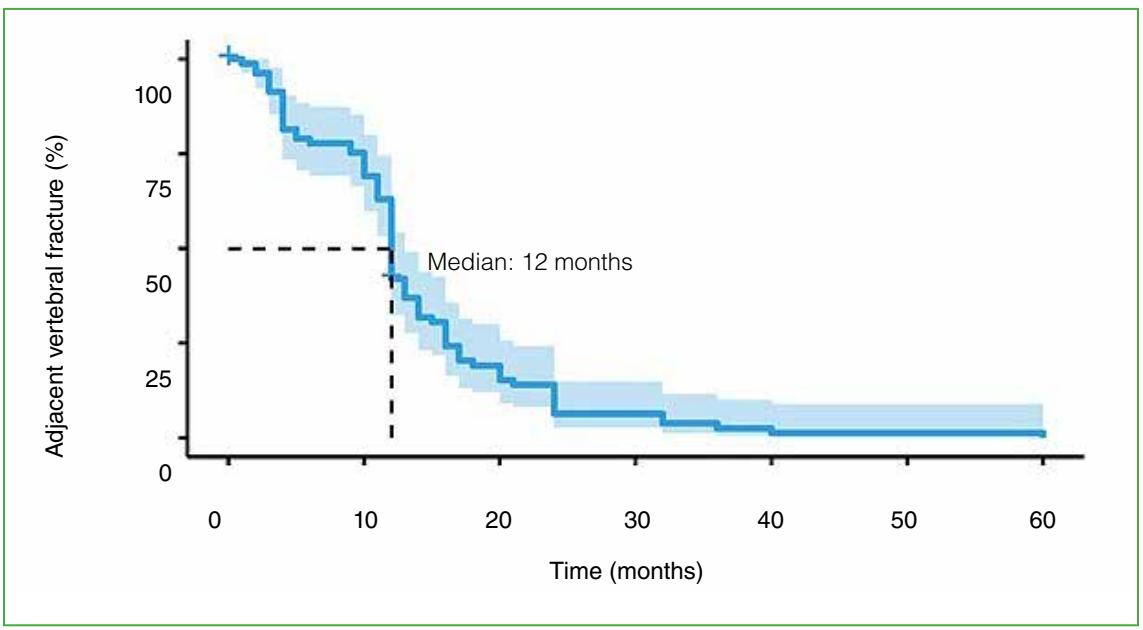

Figure 1. ROC curve of the average Hounsfield unit (HU) value below the fracture for predicting vertebral refracture.

Refracture-free survival, estimated using Kaplan–Meier curves, was 12 months (Figure 2).

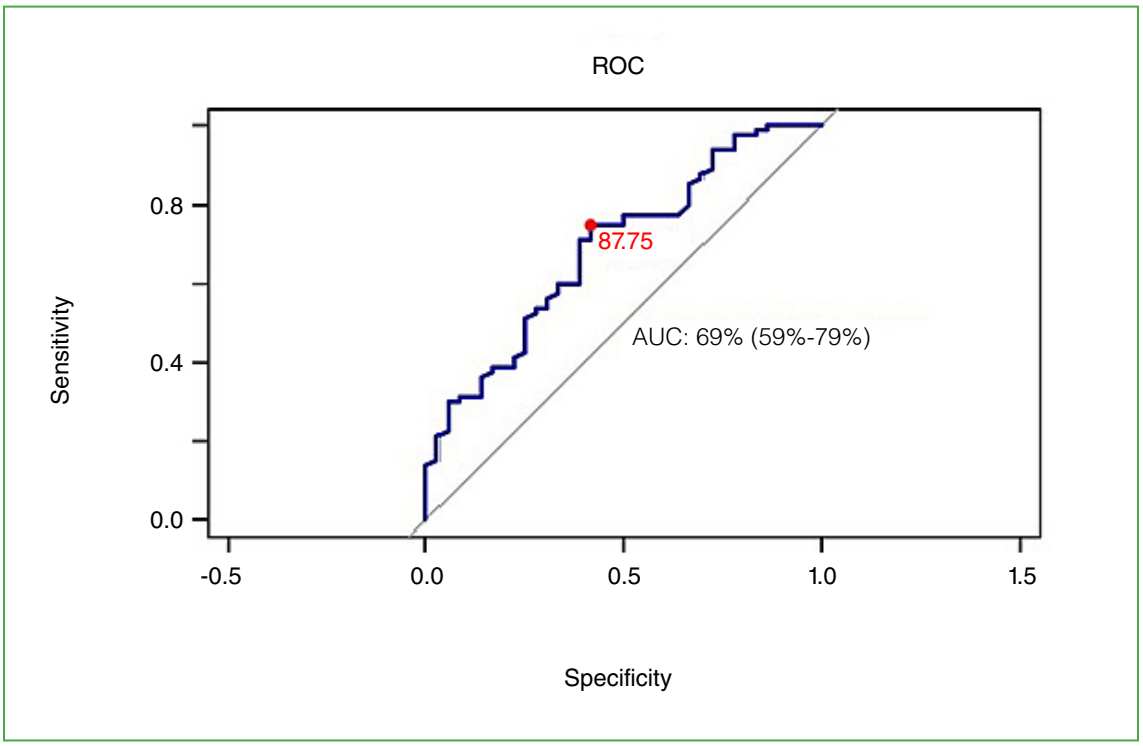

Figure 2. Time to refracture estimated using the Kaplan–Meier survival curve.

DISCUSSION

This study provides a comprehensive overview of vertebral refracture after vertebroplasty and the factors associated with its occurrence, with particular emphasis on the role of previous fractures and bone density in adjacent segments. Our main finding was that lower average bone density in the vertebrae located below the fractured level, measured in Hounsfield units (HU), constituted an independent risk factor for refracture following vertebroplasty.

An association between previous vertebral fractures and an increased incidence of new fractures in adjacent segments has been widely reported.[4] An initial fracture may predispose patients to subsequent fractures due to biomechanical alterations that modify load distribution along the spine, thereby increasing stress on neighboring vertebrae, particularly in inferior segments. Melton[5] previously demonstrated that vertebral fractures can weaken the surrounding bone structure, favoring the development of additional fractures. In our cohort, patients with prior fractures and a greater number of fractured vertebrae showed a higher refracture rate; however, these variables did not retain statistical significance in the multivariable analysis.

En investigaciones previas, se ha señalado que el uso prolongado de corticoides puede llevar a una reducción significativa en la densidad mineral ósea, incrementando el riesgo de fracturas.[6] Aunque, en nuestro estudio, el uso de corticoides no fue estadísticamente significativo como factor de riesgo para las refracturas, es importante señalar que los pacientes del grupo CF usaban el doble de corticoides que los del grupo SF (SF 5,56% vs. CF 11,25%). Esto sugiere que, aunque no hubo un impacto directo en los resultados, no se debe subestimar el efecto acumulativo de los corticoides en la salud ósea a largo plazo.

Our results also indicate that patients with a history of vertebral fractures exhibit lower bone density in adjacent segments, which may reflect structural weakening and increased vulnerability to refracture. This observation is consistent with the findings of Sornay-Rendu et al.,[7] who identified previous vertebral fractures as a strong pre-

dictor of bone loss in neighboring vertebrae. Together, these findings reinforce the concept that prior fractures contribute substantially to progressive deterioration of spinal bone health.

Identification of these risk factors is critical for optimizing clinical management. In this context, the cutoff value of 87.75 HU in vertebrae located below the fracture level, derived from ROC curve analysis, demonstrated a sensitivity of 75% and a specificity of 58%. This threshold may facilitate early identification of patients at increased risk of refracture. A preventive strategy incorporating regular monitoring of patients with previous fractures and application of this HU-based threshold could help reduce the incidence of new fractures. Additional interventions—such as bisphosphonate therapy, promotion of physical activity, and fall-prevention education—remain essential components of comprehensive osteoporosis management. This approach aligns with the 2019 World Health Organization recommendations, which emphasize early intervention in high-risk populations.

Several limitations of this study should be acknowledged. Its retrospective design may introduce selection bias and limits causal inference. Additionally, the study population was drawn from a single center, which may restrict the generalizability of the findings. Finally, the relatively small sample size may have limited the statistical power of certain analyses.

CONCLUSIONS

Patients with an average HU value below 87.75 in the vertebrae inferior to the fractured level are at increased risk of refracture after vertebroplasty. This finding establishes a clinically useful threshold for identifying particularly vulnerable individuals. In such patients, closer follow-up and proactive prevention-oriented education are recommended, as these strategies may improve quality of life and reduce morbidity associated with subsequent fractures.

Prospective studies are warranted to determine whether targeted interventions—such as preventive cement augmentation in this high-risk subgroup—could provide benefits beyond those achieved with conventional follow-up alone.

Conflict of interest: The authors declare no conflicts of interest.

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