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ORIGINAL ARTICLE

# Hypovitaminosis D as a risk factor of hip fracture severity

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**Abstract**
*Summary* In a cross-sectional study including 324 patients older than 65 years admitted to our hospital for osteoporotic hip fracture, we found that those patients with a more severe vitamin D deficiency had more severe osteoporotic hip fractures (Garden grades III–IV and Kyle III–IV).
*Introduction* To identify possible differences in baseline characteristics of patients with different types of osteoporotic hip fracture.
*Methods* Cross-sectional study including consecutive individuals over 65 admitted to our hospital for osteoporotic hip fracture over a year. Demographic data, fracture type, comorbidities, history of osteoporosis, functional capacity, nutritional status and vitamin D storage were evaluated.
*Results* We included 324 patients (83±7 years, 80% women). Two hundred sixteen patients (67%) had vitamin D deficiency (25OHD3 <25 ng/ml). In patients with severe femoral neck or intertrochanteric fractures (Garden III–IV and Kyle III–IV), vitamin D deficiency was more frequent (74%) and severe (25OHD3 20±15 ng/ml) than in patients with less severe fractures (57%, 25OHD3 26±21 ng/ml). Forty-three percent of patients had previous fractures. Only 15% of patients had been previously diagnosed with osteoporosis and 10% were receiving treatment. Patients receiving vitamin D supplements have higher 20OHD3 levels and less severe fractures.
*Conclusions* Although vitamin D levels are not different between patients with intracapsular or extracapsular hip fractures, a more severe vitamin D deficiency seems to be associated to more severe osteoporotic hip fractures. A prior vitamin D supplementation could avoid a higher severity of these fractures.

**Keywords** Functional status · Hip fracture · Hypovitaminosis D · Nutritional status · Osteoporosis · Parathyroid hormone

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## Introduction

Among osteoporotic fractures hip fracture is the one associated with the most important morbidity and mortality [1–5] and with higher socioeconomic costs [6], representing a major health problem in developed countries. Although hip fracture is usually considered in the most of studies as a homogeneous condition, there are two main types of hip fracture according to the involved anatomic site: fractures of the femoral neck (intracapsular fractures) and fractures of the intertrochanteric region (extracapsular fractures) that can have different characteristics and different outcomes. The clinical presentation of hip fracture has gradually evolved over recent decades. Along with average age of individuals, the proportion of extracapsular fractures and mortality of patients have also increased [7]. Some studies

suggested that patients with fracture of the trochanteric region have some common characteristics such as older age, pre-fracture poor health status or a higher prevalence of hypovitaminosis D [8], although these data are not well established. Outcomes may vary also by the severity of the hip fracture, and therefore it is clinically important to distinguish between the type and the severity of hip fracture [9]. In a recent study by Cornwall et al. [10], mortality was the lowest for patients with undisplaced (less severe) femoral neck fractures and highest for patients with displaced fractures (more severe). Also, after 6 months of follow-up, functional outcome was the best for those who experienced an undisplaced femoral neck fracture and the worst for patients with unstable or more severe intertrochanteric fractures.

This study aims to analyze baseline differences between patients with different types of osteoporotic hip fracture.

## Patients and methods

A cross-sectional study was performed including consecutive individuals over 65 who were admitted to our hospital for an osteoporotic hip fracture between March 2002 and February 2003. A fracture was considered osteoporotic when presented after a low impact trauma, such as a fall from a standing height. The following variables were collected from all patients: age, gender, type of femur fracture, health status and functional capacity prior to fracture, laboratory parameters of phospho-calcium metabolism and nutritional status, existence of a prior diagnosis of osteoporosis (OP), presence and location of fragility fractures occurring after age 50 and whether the patient was treated for OP in the past 6 months (including calcium and vitamin D).

Hip fracture was classified according to anatomical location, such as fracture of the femoral neck or intracapsular (subcapital and basicervical fractures) and fracture of trochanteric or extracapsular region (intertrochanteric and subtrochanteric fractures) [9].

Femoral neck fractures were classified according to the degree of displacement of the femoral head in relation to the femoral neck (Garden classification [11]) (Fig. 1), while intertrochanteric fractures were classified according to fragmentation and displacement of the fracture (Kyle classification [12]) (Fig. 2).

Serum samples for phospho-calcium metabolism study, including serum calcium (Ca), phosphorus (P), alkaline phosphatase (ALP), vitamin D storage (25OHD3) and intact parathyroid hormone (iPTH), and also, parameters of nutritional status (transferrin, albumin, prealbumin and total lymphocyte count) were obtained in all patients at admission to the hospital, always before surgical intervention.

Determinations of Ca, P and P were performed on a Hitachi 717 biochemical analyzer (Roche Diagnostics, Mannheim, Germany) with reagents of the same commercial brand, with their reference values: Ca 8.4–10.2 mg/dl, P 2.7–4.5 mg/dl and ALP 35–104 U/L.

We also calculated the corrected calcium, using the formula: corrected Ca (mg/dl)=[40−albumin (g/l)/10]+Ca (mg/dl).

Serum 25OHD3 was determined by radioimmunoassay (DIA Sorin, Minnesota, USA), and concentrations between 25–95 ng/ml were considered normal. The iPTH was determined by radioimmunoassay (Nichols Institute, California, USA), reference values between 10–65 pg/ml. We defined the presence of hypovitaminosis D as serum 25OHD3 below 25 ng/ml and secondary hyperparathyroidism as serum iPTH concentrations above 65 pg/ml in the presence of hypovitaminosis D.

Patients who also had renal insufficiency with possible secondary hyperparathyroidism (defined as creatinine >1.3 mg/dl in women and >1.5 mg/dl in men) [13] were excluded.

The determinations of transferrin and prealbumin were performed by nephelometry, with reference values 200–360 mg/dl and 20–40 mg/dl, respectively. Determination of albumin was performed using a colorimetric method with green bromocresol and normal values were considered 34–48 g/l. The normal total lymphocyte count was $1–4.5\times10^9$/L.

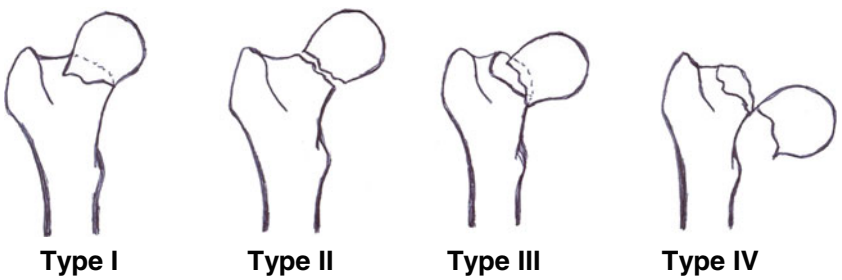


**Fig. 1** Femoral neck fractures according to Garden classification. Type I—incomplete or impacted fracture, in which bone structure is preserved at the bottom of the femoral neck. Type II—complete fracture without displacement of fragments. Type III—complete fracture with partial displacement of the bone fragments. Type IV—complete fracture with total displacement of the bone fragments

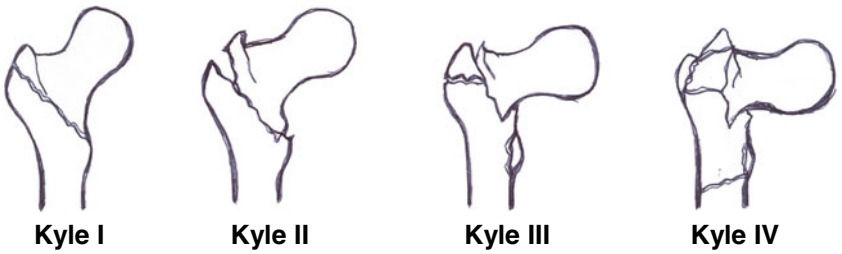


**Fig. 2** Intertrochanteric fractures according to Kyle classification. Kyle I—trochanteric region with a single fracture line without displacement of the two fragments. Kyle II—stable fracture with displaced varus proximal fragment and minimal comminution. Kyle III—unstable fracture with displaced varus proximal fragment. Kyle IV—similar to Kyle III but with extension of the fracture at the subtrochanteric region

Health status was estimated from the number of comorbid conditions without considering the surgical history (diabetes, hypertension, dementia, arthritis, asthma, chronic obstructive pulmonary disease, ischemic heart disease or kidney failure among others) and the total number of drugs the patient was taking, as referred by the patient, family members or caregivers.

The pre-fracture functional capacity was measured using the Barthel index [14] (values 0–100, in which the value 100 indicates the maximum capacity), the index of independence in activities of daily living (ADL index) [15] (values 0–6, with 6 reflecting total dependence), and a questionnaire assessing walking ability if the patient was independent or whether the patient needed technical aids or was unable to walk.

Baseline characteristics were compared between patients with intracapsular and extracapsular hip fractures and between less severe hip fractures (Garden I–II and Kyle I–II) and more severe fractures (Garden III–IV and Kyle III–IV).

### Statistical analysis

Statistical analysis was conducted using SPSS 13.0. Qualitative variables are expressed as frequencies and percentages with confidence intervals (CI), whereas quantitative variables are expressed as mean ± standard deviation ($X \pm SD$). The chi-square distribution was used for the analysis of the qualitative variables and the Student's $t$ distribution (when comparing two groups) or analysis of variance of a factor (when comparing more than two groups) for quantitative variables and comparison between means. Differences were considered significant if $p \leq 0.05$.

A logistic regression analysis was performed to determine those variables associated higher risk of more serious fracture. This was preceded by an analytical study to identify significant variables with posterior assessment of the existence of collinearity among the variables. The analysis was carried backward and forward stepwise with a variable number of interactions, estimating the odds ratio (OR), CI 95% and the degree of significance. Results were considered statistically significant if $p$ value $\leq 0.05$.

To carry out this study, the approval of the ethics committee of our hospital as well as informed consent from participating patients were obtained.

## Results

### Patient characteristics

After excluding 6 patients with renal impairment (as we previously defined) and 3 patients with liver disease and ALP between 600 and 2,000 U/L, we included 324 individuals with hip fractures, 65 men (20%) and 259 women (80%), aged 83±7 years (65–98 years). The right hip was affected in 176 (55%) of cases. The descriptive characteristics of the group are listed in Table 1.The study of phospho-calcium metabolism showed mean concentrations of Ca, corrected Ca and P within the normal range. The average value of 25OHD3 was 23±18 ng/ml and that of iPTH was 85±59 pg/ml. A histogram shows the 25OHD3 levels distribution (Fig. 3).

Two hundred and sixteen patients (67%) had hypovitaminosis D and 177 (55%) secondary hyperparathyroidism. Patients with hypovitaminosis D were significantly older than patients with normal 25OHD3 (84±7 vs. 81±8 years, $p=0.01$).

Likewise, patients with hyperparathyroidism were older than those with normal PTH levels (84±7 vs. 81±8 years, $p=0.01$).

The study of nutritional status (transferrin, albumin, prealbumin and total lymphocyte count) showed values within normal ranges.

The data on previous diagnosis and treatment of osteoporosis could be collected in 307 patients. Fifteen percent of patients had been previously diagnosed with OP and 43% reported having suffered previous fractures. Seventy-three percent of patients diagnosed with OP had had previous fractures. In 57% of patients, the current hip fracture was the first osteoporotic fracture. Only 10% (30 patients) had received treatment for osteoporosis in the previous 6 months (9% of patients received calcium

**Table 1** Baseline characteristics of the 324 patients

| | | 324 patients | 259 women (80%) | 65 male (20%) |
|---|---|---|---|---|
| | | 83±7.1 | 83±7.2 | 81.7±8.0 |
| Comorbidity | No | 4 (1%) | 4 (1%) | 0 |
| | 1–3 Diseases | 207 (64%) | 167 (52%) | 40 (12%) |
| | Four or more diseases | 111 (34%) | 87 (27%) | 24 (7%) |
| Number of drugs | 0 | 20 (6%) | 17 (5%) | 3 (1%) |
| | 1–3 | 137 (43%) | 111 (34%) | 26 (8%) |
| | Four or more | 161 (51%) | 127 (39%) | 34 (11%) |
| Subcapital | | 114 (35%) | 90 (28%) | 24 (7%) |
| Basicervical | | 14 (4%) | 10 (3%) | 4 (1%) |
| Intertrochanteric | | 164 (51%) | 133 (41%) | 31 (10%) |
| Subtrochanteric | | 32 (10%) | 26 (8%) | 6 (2%) |
| Barthel index | | 76±24 | 75±27 | 79±24 |
| ADL index | | 2.2±2.2 | 2.3±2.2 | 2.1±2.2 |
| Ability to progress | Even stairs | 67 (21%) | 56 (17%) | 11 (4%) |
| | Independent walking | 97 (30%) | 81 (25%) | 16 (5%) |
| | Use of cane | 110 (34%) | 80 (25%) | 30 (9%) |
| | Walkers | 26 (8%) | 25 (8%) | 1(<1%) |
| | Impossibility | 15 (5%) | 12 (4%) | 3 (1%) |
| Ca (8.4–10.2 mg/dl) | | 9.3±0.8 | 9.3±0.8 | 9.1±0.8 |
| P (2.7–4.5 mg/dl) | | 3.2±0.7 | 3.2±0.7 | 3.1±0.8 |
| Corrected Ca | | 9.5±0.6 | 9.6±0.6 | 9.4±0.6 |
| ALP (35–104 U/l) | | 93±37 | 98.4±104.1 | 142.1±275.1 |
| 25(OH)D3 (25–95 ng/ml) | | 23±18 | 22.5±18.6 | 22.9±15.5 |
| iPTH (10–65 pg/ml) | | 85±59 | 85.5±60.2 | 82.9±54.2 |
| Hypovitaminosis D (%) | | 216 (67%) | 178 (55%) | 39 (12%) |
| Hyperparathyroidism (%) | | 177 (55%) | 144 (44%) | 33 (10%) |
| Albumin (34–48 g/l) | | 38±4 | 38±4 | 37.9±5.4 |
| Prealbumin (20–40 mg/dl) | | 21±7 | 20.4±6.1 | 22.1±7.9 |
| Transferrin (200–360 mg/dl) | | 224±48 | 225.3±47.2 | 219.1±53.8 |
| Total lymphocyte count (1–4.5×$10^9$/l) | | 1.5±0.8 | 1.5±0.8 | 1.3±0.7 |
| Previous diagnosis osteoporosis | | 48 (15%) | 44 (14%) | 4 (1%) |
| Previous fractures | No | 185 (58%) | 130 (41%) | 55 (17%) |
| | Wrist | 42 (15%) | 33 (14%) | 3 (1%) |
| | Vertebral | 24 (9%) | 21 (8%) | 3 (1%) |

*ALP*: Alkaline phosphatase

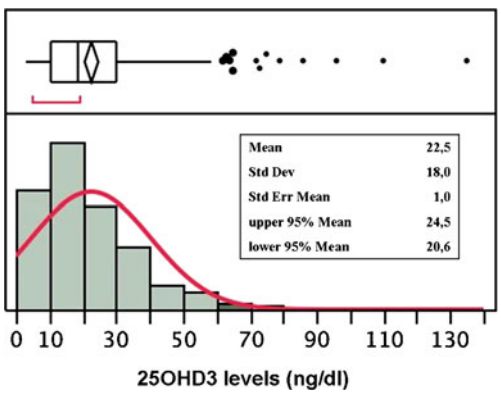


**Fig. 3** 25OHD3 levels distribution

supplementation, 4% vitamin D, 1% bisphosphonates and 3% calcitonin).

Patients receiving vitamin D supplementation have higher 25OHD3 levels than patients not receiving those supplements (51.6±31.6 vs. 21.4±16.1 ng/ml; $p<0.05$)

Comparison between patients with intracapsular fracture (subcapital or basicervical fractures) and extracapsular fracture (intertrochanteric or subtrochanteric fractures)

When comparing the 128 individuals with intracapsular fracture (39.5%) with the 196 patients with extracapsular fracture (60.5%) in the univariate analysis, patients with intracapsular fractures were younger (82±7 vs. 83±8 years), with the difference in the limit of statistical significance

($p$=0.06). There was no difference in gender, health status, serum vitamin D levels or functional status. Table 2 shows the comparative results between these two groups.

Patients with extracapsular fracture showed higher levels of serum P (3.2±0.7 vs. 3.1±0.7 mg/dl, $p$=0.03) and iPTH (91±64 vs. 76±49 pg/ml, $p$=0.03). These individuals had secondary hyperparathyroidism more often (60%) than patients with intracapsular fracture (47%, $p$=0.02).

The nutritional study only showed differences in the total number of lymphocytes ($1.4\pm0.6\times10^9$/l vs. $1.6\pm0.9\times10^9$/l, $p$=0.01). We found no difference in other parameters studied between groups.

A greater percentage of patients with extracapsular fracture had suffered previous osteoporotic fractures compared with patients with intracapsular fracture (48% vs. 33% $p$=0.01).

Patients receiving vitamin D supplementation, although have higher 25OHD3 levels, did not show any difference in the type of hip fracture.

## Comparison between patients with less severe femoral neck or intertrochanteric fractures (Garden I–II and Kyle I–II) and more severe fractures (Garden III–IV and Kyle III–IV)

Table 3 shows the comparative data of the 131 patients (40%) with less severe femoral neck and intertrochanteric fractures and of the 193 patients (60%) who had more severe fractures.

**Table 2** Comparison between patients with intracapsular fracture (subcapital and basicervical) and extracapsular fracture (subtrochanteric and pertrochanteric)

| Variable $X$±SD | | | Intracapsular fracture (128 patients) | Extracapsular fracture (196 patients) | $P$ |
|---|---|---|---|---|---|
| Age | | | 82±7 | 83±8 | 0.06 |
| Sex, female (% patients) | | | 99 (80%) | 177 (81%) | NS |
| Health status | Comorbidity | No | 2 (2%) | 2 (1%) | NS |
| | | 1–3 Diseases | 88 (70%) | 119 (61%) | NS |
| | | Four or more diseases | 36 (29%) | 75 (38%) | NS |
| | No drugs | 0 | 6 (5%) | 14 (7%) | NS |
| | | 1–3 | 53 (43%) | 84 (43%) | NS |
| | | More than 4 | 65 (52%) | 96 (50%) | NS |
| Functional capacity | Barthel index | | 76±25 | 76±23 | NS |
| | ADL index | | 3.3±2.3 | 3.3±2.3 | NS |
| | Ability to progress | Even stairs | 29 (23%) | 38 (20%) | NS |
| | | Independent walking | 39 (31%) | 50 (31%) | NS |
| | | Use of cane | 38 (31%) | 72 (37%) | NS |
| | | Walkers | 12 (10%) | 14 (7%) | NS |
| | | Impossibility | 6 (5%) | 9 (5%) | NS |
| P–Ca metabolism | Ca (8.4–10.2 mg/dl) | | 9.3±0.8 | 9.3±0.8 | NS |
| | P (2.7–4.5 mg/dl) | | 3.1±0.7 | 3.2±0.7 | 0.03 |
| | Corrected Ca | | 9.5±0.5 | 9.5±0.6 | NS |
| | ALP (35–104 U/l) | | 95±43 | 92±34 | NS |
| | 25OHD3 (25–95 ng/ml) | | 22.5±18 | 22.6±18 | NS |
| | iPTH (10–65 pg/ml) | | 76±49 | 91±64 | 0.03 |
| | Hypovitaminosis D (% patients) | | 82 (64%) | 134 (69%) | NS |
| | Hyperparathyroidism (% patients) | | 60 (47%) | 117 (60%) | 0.02 |
| Nutrition parameters | Albumin (34–48 g/l) | | 38±4 | 38±4 | NS |
| | Prealbumin (20–40 mg/dl) | | 21±7 | 21±6 | NS |
| | Transferrin (200–360 mg/dl) | | 224±50 | 223±47 | NS |
| | Total lymphocyte count ($1–4.5\times10^9$/l) | | 1.4±0.6 | 1.6±0.9 | 0.01 |
| Previous diagnosis OP (% patients) | | | 18 (15%) | 30 (16%) | NS |
| Previous fractures (% patients) | | | 42 (33%) | 92 (48%) | 0.01 |

*ALP*: Alkaline phosphatase

*NS*: Not significant

**Table 3** Comparison between patients with less severe (grades I–II Garden and Kyle I–II) and more severe (grades III–IV Garden and Kyle III–IV) subcapital or pertrochanteric

| Variable $X \pm$ SD | | | Less severe fractures (131 patients) | More severe fractures (193 patients) | $P$ |
|---|---|---|---|---|---|
| Age | | | 82±8 | 83±7 | NS |
| Sex, female (% patients) | | | 104 (79%) | 155 (80%) | NS |
| Health status | Concomitant illnesses | No | 3 (2%) | 1 (0.5%) | NS |
| | | 1–3 Diseases | 78 (60%) | 129 (67%) | NS |
| | | Four or more diseases | 49 38 (%) | 62 (32%) | NS |
| | No drugs | 0 | 8 (6%) | 12 (6%) | NS |
| | | 1–3 | 56 (44%) | 81 (43%) | NS |
| | | More than 4 | 64 (50%) | 97 (51%) | NS |
| Functional capacity | Barthel index | | 78±23 | 74±24 | NS |
| | ADL index | | 3.5±2.4 | 3.2±2.2 | NS |
| | Ability to progress | Even stairs | 36 (28%) | 31 (17%) | NS |
| | | Independent walking | 40 (31%) | 58 (31%) | NS |
| | | Use of cane | 39 (30%) | 71 (38%) | NS |
| | | Walkers | 9 (7%) | 17 (9%) | NS |
| | | Impossibility | 5 (4%) | 0 (5%) | NS |
| P–Ca metabolism | Ca (8.4–10.2 mg/dl) | | 9.3±0.8 | 9.2±0.8 | NS |
| | P (2.7–4.5 mg/dl) | | 3.1±0.6 | 3.2±0.7 | NS |
| | Corrected Ca | | 9.5±0.6 | 9.5±0.6 | NS |
| | ALP (35–104 U/l) | | 88±28 | 92±33 | NS |
| | 25OHD3 (25–95 ng/ml) | | 26±21 | 20±15 | 0.004 |
| | iPTH (10–65 pg/ml) | | 80±55 | 89±61 | NS |
| | Hypovitaminosis D (% patients) | | 74 (57%) | 142 (74%) | 0.002 |
| | Hyperparathyroidism (% patients) | | 63 (48%) | 114 (59%) | 0.05 |
| Nutrition parameters | Albumin (34–48 g/l) | | 38±5 | 38±4 | NS |
| | Prealbumin (20–40 mg/dl) | | 21±7 | 21±6 | NS |
| | Transferrin (200–360 mg/dl) | | 224±51 | 224±47 | NS |
| | Total lymphocyte count (1–4.5×$10^9$/l) | | 1.5±0.8 | 1.5±0.8 | NS |
| Previous diagnosis OP (% patients) | | | 23 (19%) | 25 (14%) | NS |
| Previous fractures (% patients) | | | 52 (41%) | 82 (43%) | NS |

*ALP*: Alkaline phosphatase

*NS*: Not significant

There was no difference in age and sex between groups. Individuals with more severe fractures showed significantly lower levels of 25OHD3 (20±15 vs. 26±21 ng/ml, $p$=0.004) and higher prevalence of hypovitaminosis D compared with patients with less severe hip fracture (74% vs. 57%, $p$=0.002). The iPTH tended to be higher in patients with more severe fractures (89±61 vs. 80±55 pg/ml) but did not reach statistical significance. Secondary hyperparathyroidism occurred more frequently among patients with more severe fractures (59% vs. 48%, $p$=0.05). No differences in other parameters (P–Ca metabolism, nutritional status, health status, functional status or presence of previous fractures) between both groups.

It is also remarkable that among patients treated with vitamin D supplements, less severe fractures were more frequent (77%; $p$=0.006)

The multiple regression analysis, including the same variables included in the univariate analysis, confirmed the levels of 25OHD3 as the only independent variable associated with severe hip fracture (OR 0.98; 95% CI 0.97–0.99; $p$=0.018). In other words, for each decrease in 1 ng/ml of 25OHD3, the risk of having a severe hip fracture increases about 2%. In fact, patients with hypovitaminosis D have a 47% higher risk of having a severe hip fracture than patients with normal vitamin D (OR 1.47; 95% CI 1.15–1.88; $p$=0.002).

## Discussion

In this study we found that patients with osteoporotic hip fracture in their severe forms, both intra and extracapsular

(Garden III–IV and Kyle III–IV), often suffer a vitamin D deficiency and this deficiency is also more intense than in patients who suffered less severe fractures.

It is known that hypovitaminosis D is more prevalent among the elderly with hip fracture [16–21]. In some small series, lower serum vitamin D levels have also been found in patients with fractures of the trochanteric region [8], which was not observed in our study. However, we are not aware that the association between the severity of osteoporotic hip fractures and hypovitaminosis D has been previously described. Vitamin D deficiency seems to play a role in the pathogenesis of these fractures, and also could be associated to their severity. In addition to the deterioration of bone metabolism caused by vitamin D deficiency, myopathy [22] could be involved. In our study the existence of myopathy among patients with more severe fractures cannot be ruled out, although no differences in prior health status, functional capacity, nutritional status or the characteristics of the underlying OP were found.

The presentation of hip fracture seems to have gradually evolved in recent decades. In parallel with the increase in the average age of individuals, an increase in the proportion of extracapsular fractures has been reported in most series [7, 23, 24]. In our series, the average age of patients was 83 years while in the series published in the 1980s, the average age was around 79 years [8, 23] and in the 1940s was around 67 years [24]. The extracapsular/intracapsular rate (60/40) in our series was similar to that of other recent studies [4] but different from those published 10 or 20 years ago, in which the two fracture types had a similar distribution [2, 8, 25].

Several authors have attempted to identify the existence of differential characteristics between patients with femoral neck fracture and trochanteric fracture with controversial results in terms of health status, nutritional status and functional capacity prior to fracture [2, 8, 26]. We have found no differences in these variables and some authors only found them in women [27]. Comparison with other studies is difficult because some of them included all types of femoral fractures, and not only those that could be considered osteoporotic fractures [8, 26].

Half of the patients in our study had secondary hyperparathyroidism. Extracapsular fracture patients showed higher levels of PTH and greater prevalence of hyperparathyroidism, which is in accordance with other publications [28, 29]. Fisher et al. [29] found that hip fracture type is significantly associated with PTH response to hypovitaminosis D and impaired phosphate homeostasis. Elevated PTH levels increase the odds for trochanteric hip fracture (each increase in serum PTH concentration of 1 pmol/l increased the risk of trochanteric vs. cervical hip fracture by 10%), while blunted PTH response to hypovitaminosis D increases odds for cervical hip fracture. They also found that this association seems to be independent of numerous confounding factors.

In our study we also found that patients with more severe fractures had more vitamin D deficiency and a higher proportion of hyperparathyroidism. In this sense Fischer et al. had also described in a different study that secondary hyperparathyroidism is also a strong independent predictor of worse prognosis in patients with hip fracture [30].

Although not all patients with hypovitaminosis D develop secondary hyperparathyroidism, the increase in PTH allows to maintain calcium homeostasis at the expense of increased bone remodeling that causes somewhat higher levels of 1,25OHD3 and an increase in bone turnover markers [28, 31]. This hypothesis, which cannot be demonstrated with the design of our study, is a plausible mechanism explaining the relationship between extracapsular fractures and more severe fractures with a greater presence of parathyroid hyperfunction.

In our series 43% of individuals reported previous fractures, with wrist fractures the more frequent. However, vertebral fractures were probably underestimated since there were no radiological studies available to their assessment. More than half of patients reported hip fracture as the first fracture. It is striking that osteoporosis was so underdiagnosed among senile patients like these in our series and that this diagnosis was established almost exclusively in patients who report previous osteoporotic fractures. Coinciding with other publications [32] is really alarming the low percentage of patients on treatment for osteoporosis, many of them with risk factors that justify antiosteoporotic therapy which probably could have prevented hip fracture in a proportion of these patients.

Although only 4% of our patients (13 patients) were receiving vitamin D supplementation (with or without calcium), we found that these patients had significantly higher 25OHD3 levels and less severe hip fractures, reinforcing the role of vitamin D in the severity of hip fractures. This finding raises the hypothesis that a sufficient supplementation of vitamin D in patients with a high risk of fracture could avoid the more severe types.

There are several limitations to our analysis. The most important is the absence of an independent interpretation of the radiographs to classify the fractures. The classification of the fracture type and severity was made by the experience of the orthopaedic surgeons, based on their own experience. Also, the two classification systems used (Garden for intracapsular fractures and Kyle for extracapsular fractures), are not the only classification systems, and do not have the support of 100% of the orthopaedic surgeons across North America and Europe [33]

Also, the low proportion of patients under treatment for osteoporosis, including calcium and vitamin D supplementation, in our population limited the possibility to analyze possible associations between the dose of vitamin D supplementation and the type or severity of fractures. Finally, the

functional capacity in patients with cognitive impairment was assessed through an interview approach with a relative or caregiver, with some possible discrepancies.

In summary, the analysis of baseline characteristics in a series of patients with osteoporotic hip fracture has shown that although vitamin D levels are not different between patients with intracapsular or extracapsular hip fracture, the largest vitamin D deficiency was associated with a more severe type of fracture in each group (femoral neck fracture Garden III and IV or intertrochanteric fracture Kyle III and IV). Our results can have some important clinical implications, highlighting a possible role of hypovitaminosis D in the severity of hip fractures that could lead to a poor functional outcome and a higher mortality of the patients. Therefore, it could be of great interest to provide a sufficient supplementation of vitamin D in older patients with a high risk of hip fracture.

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**Conflicts of interest** None.

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