



# Vitamin D Levels in Patients with Low-energy Hip Fractures

Jaehwi Han, MD, Youngho Cho, MD, Seungmin Jee, MD, Seongwoo Jo, MD

*Department of Orthopaedic Surgery, Daegu Fatima Hospital, Daegu, Korea*

**Purpose:** To evaluate serum 25(OH) vitamin D levels in patients with low-energy hip fractures.

**Materials and Methods:** Among 983 patients who underwent hip fracture surgery between August 2013 and March 2019, 732 patients were evaluated. The remaining patients were excluded due to the presence of one or more of the following: metastatic bone tumor, metabolic bone disease other than osteoporosis, fracture due to high-energy injury, atypical femoral fracture, and no blood test. We collected patient's data about age, sex male female, date of injury, a place of residence, fracture type, preinjury ambulation ability according to their Koval score, and their serum level of 25(OH) vitamin D. The mean age was 79.3 years (60-104 years). The sample was comprised of 530 female and 202 male, of which 342 had femoral neck fractures and 390 had trochanteric fractures.

**Results:** Of the total 732 patients, 346 patients (47.3%) had a 25(OH) vitamin D level of less than 10 ng/mL, 264 patients (36.1%) had scores of 10-19.9 ng/mL, 87 patients (11.9%) had scores of 20-29.9 ng/mL, and 35 patients (4.8%) had a level higher than 30 ng/mL. Vitamin D deficiency (less than 20 ng/mL) was present in 610 patients (83.3%), insufficiency (20-29.9 ng/mL) was found in 87 patients (11.9%), and 35 patients (4.8%) had normal vitamin D levels. The differences in vitamin D concentration based on season and fracture type were statistically significant.

**Conclusion:** Vitamin D deficiency and inadequacy were high in patients with low-energy hip fractures, with only 4.9% of patients had normal vitamin D levels. These findings suggest that efforts should be made to maintain proper vitamin D concentration.

**Key Words:** Low energy, Hip fractures, Vitamin D

## INTRODUCTION

Vitamin D is mostly produced by sunlight and can be consumed as food like fish oils and mushrooms. In the United States, many vitamin D-fortified foods like milk, cereal, and orange juice account for most of the vitamin D intake<sup>1)</sup>, but these foods are not common in Korea. Furthermore, the photobiogenesis of vitamin D<sub>3</sub> in the skin has been reduced by modern lifestyles which include large amounts of time indoors during work hours and recreational activities, in addition to the frequent use of sunscreen and higher levels of air pollution. Vitamin D deficiency has been reported at a high rate in various popu-

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**Address reprint request to**

**Youngho Cho, MD**

(<https://orcid.org/0000-0002-1527-7761>)

Department of Orthopaedic Surgery, Daegu Fatima Hospital, 99

Ayang-ro, Dong-gu, Daegu 41199, Korea

**TEL:** +82-53-940-7324 **FAX:** +82-53-954-7417

**E-mail:** femur1973@gmail.com

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lation groups regardless of ages, races, places of residence, and disease<sup>2-6</sup>.

Hip fracture has been recognized as the most serious consequence of osteoporosis due to its potential complications, which include chronic pain, disability, diminished quality of life, and premature death. Various efforts have been made to reduce osteoporotic hip fractures, including vitamin D administration<sup>7</sup>. Vitamin D deficiency causes muscle weakness and increases the risk of falls and hip fractures<sup>8,9</sup>, and some reports found that the administration of vitamin D is sufficient to reduce the risk of falls by more than 20%<sup>10</sup>. Therefore, vitamin D deficiency may be a risk factor for osteoporotic hip fractures. For this reason, special attention should be paid to vitamin D deficiency in patients with osteoporosis. Although there are some controversies over what level of vitamin D is considered normal, several studies in different countries reported a prevalence of vitamin D deficiency in 50% to 94.2%<sup>11</sup> of patients with hip fractures<sup>11-17</sup>. Due to limited data on a relationship between vitamin D and hip fractures in Korea, the aim of the current study was to evaluate the vitamin D status in patients with low-energy hip fractures in Korea specifically.

## MATERIALS AND METHODS

Between August 2013 and March 2019, a retrospective radiographic review was conducted of all patients who suffered from a proximal femoral fracture. During this period, 983 patients with proximal femoral fractures were found. We excluded patients with metastatic bone tumor, metabolic bone disease other than osteoporosis, fracture due to high-energy injury, atypical femoral fracture, and any records missing a blood test for 25(OH) vitamin D. After exclusions, a total of 732 patients with hip fractures were enrolled in this study.

We collected demographic data on age, sex, date of injury, place of residence, fracture type, preinjury ambulation ability according to Koval score<sup>18</sup> and serum level of 25(OH) vitamin D.

All blood samples were taken in the emergency room during the preoperative evaluation. Vitamin D was measured by chemiluminescent microparticle immunoassay on the Architect-I2000 system (Abbott Diagnostics, Abbott Park, IL, USA). Vitamin D deficiency was defined as a serum 25(OH) vitamin D lesser than 20 ng/mL, relative insufficiency was defined as 20 to 29 ng/mL, and patients were categorized as having sufficient vitamin D if levels were more than 30 ng/mL<sup>2</sup>.

Chi-squared tests were used for comparison between categorical variables, and a Mann-Whitney *U*-test was used for continuous variables. Statistical significance was set at a *P*-value less than 0.05. Data analysis was performed using SPSS ver. 22.0 (IBM Corp., Armonk, NY, USA).

Institutional Review Board of the Daegu Fatima Hospital approval was obtained prior to beginning this study (DFE20ORIO078-R1).

## RESULTS

A total of 732 patients with a low-energy hip fracture were enrolled in this study. The mean age of the patients was 79.3 years (60-104 years). There were 84 patients in their 60s, 276 in 70s, 314 in 80s, and 58 in their 90s or older. There were 530 females (72.4%) and 202 males. Six-hundred ten patients (83.3%) lived at home prior to their

**Table 1.** Basic Demographics of Patients

Characteristic	Value
Age (yr)	79.3 (60-104)
60-69	84 (11.5)
70-79	276 (37.7)
80-89	314 (42.9)
≥90	58 (7.9)
Sex	
Female	530 (72.4)
Male	202 (27.6)
Residence	
Home	610 (83.3)
Nursing hospital	50 (6.8)
Nursing home	72 (9.8)
Preinjury ambulation ability	
Independent community ambulatory (Koval I)	408 (55.7)
Community ambulatory with cane/walker (Koval II)	137 (18.7)
Independent household ambulatory (Koval III)	118 (16.1)
Household ambulatory with cane/walker (Koval IV)	39 (5.3)
Activity confined to room (Koval V)	12 (1.6)
Non-ambulator (Koval VI)	18 (2.5)
Season	
Spring (March-May)	175 (23.9)
Summer (June-August)	162 (22.1)
Fall (September-November)	193 (26.4)
Winter (December-February)	202 (27.6)
Fracture type	
Extra-capsular fracture	390 (53.3)
Intra-capsular fracture	342 (46.7)

Values are presented as mean (range) or number (%).

injury, 50 were in a nursing hospital setting, and 72 were in nursing homes. Five-hundred forty-five patients (74.5%) were community ambulators, 157 were household ambulators, 12 were activity confined to their rooms, and 18 were

non-ambulatory. One-hundred seventy-five hip fractures occurred in the spring, 162 in the summer, 193 in the fall, and 202 in the winter. Three-hundred ninety patients (53.3%) had an extra-capsular fracture (Table 1).

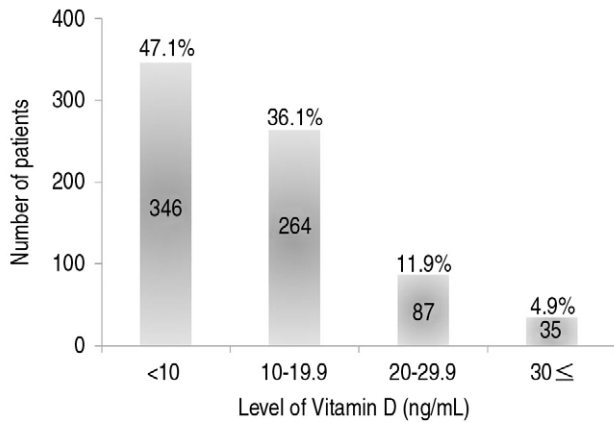


Fig. 1. Distribution of 732 patients according to level of vitamin D.

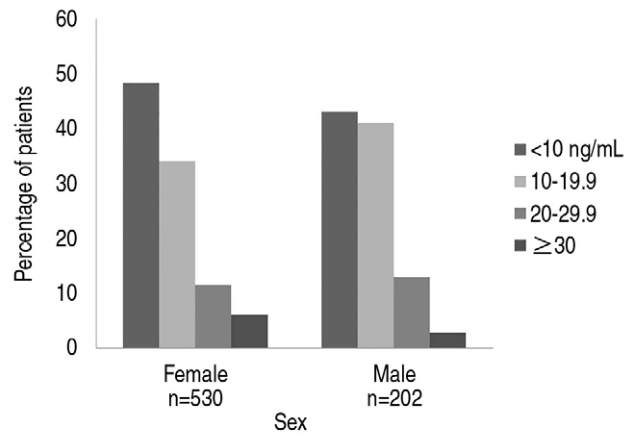


Fig. 2. Distribution of patients according to vitamin D level by sex.

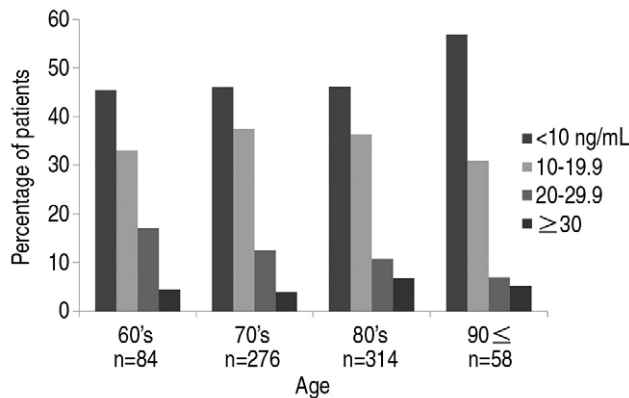


Fig. 3. Distribution of patients according to vitamin D level by age.

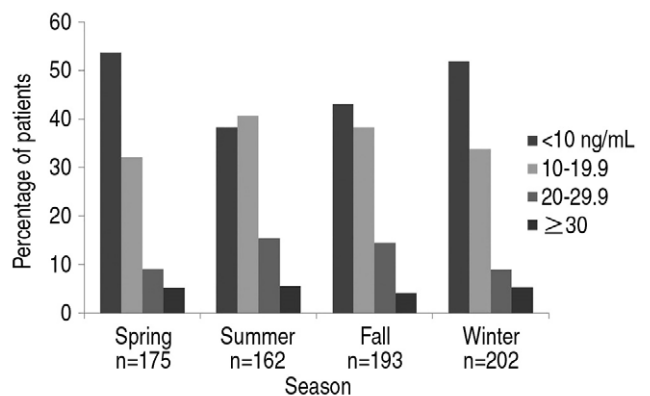


Fig. 4. Distribution of patients according to vitamin D level by season.

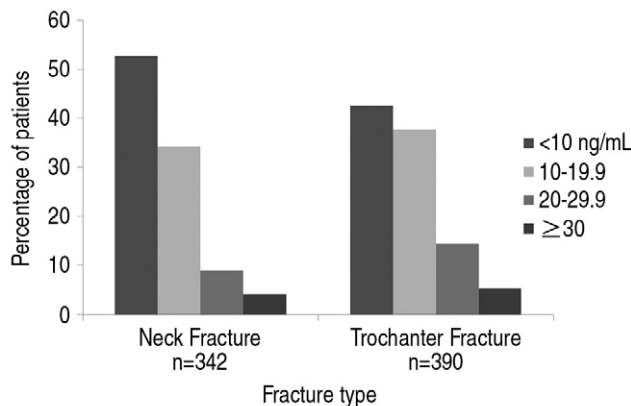


Fig. 5. Distribution of patients according to vitamin D level by type of fracture.

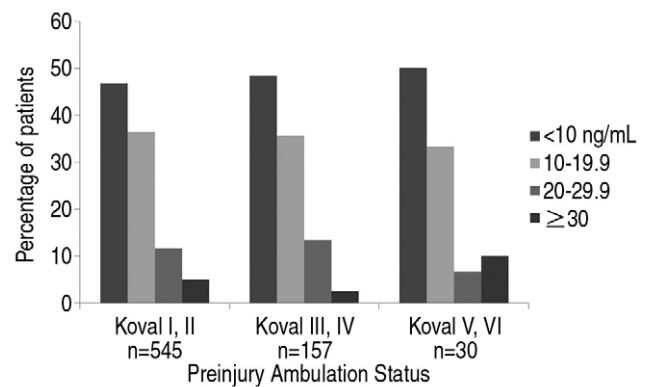


Fig. 6. Distribution of patients according to vitamin D level by preinjury ambulation.

The average vitamin D level overall was 12.9 ng/mL (2-61.7 ng/mL). Of the total 732 patients, 346 patients (47.1%) had a 25(OH) vitamin D level of less than 10 ng/mL, 264 patients (36.1%) had a level between 10-19.9 ng/mL, 87 patients (11.9%) had levels between 20-29.9 ng/mL, and 35 patients (4.9%) had a level above 30 ng/mL. Vitamin D deficiency (less than 20 ng/mL) was present in 610 patients (83.2%), insufficiency (20-29.9 ng/mL) was present in 87 patients (11.9%), and normal levels (more than 30 ng/mL) were found in only 35 patients (4.9%) (Fig. 1).

Each figure shows the distribution of patients according to vitamin D level by sex, age, season, type of fracture, pre-injury ambulation status, and residential setting (Fig. 2-7).

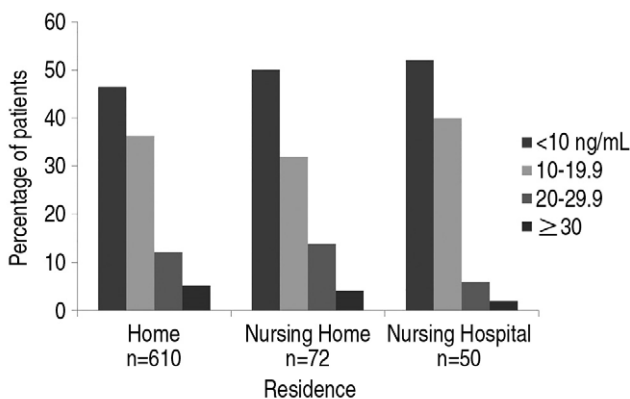


Fig. 7. Distribution of patients according to vitamin D level by residence.

Subgroup analysis found no statistically significant differences in vitamin D concentration according to age, sex, residence, or preoperative ambulation status. However, the differences in vitamin D concentration according to season and type of fracture were found to be statistically significant (Table 2).

DISCUSSION

Vitamin D deficiency is a worldwide health care problem in elderly populations, similar to osteoporosis. In particular, Korea is one of the countries with the highest reports of vitamin D deficiency<sup>19</sup>. Though the term ‘Vitamin D deficiency’ is used commonly, debates on optimal blood level of 25(OH) vitamin D continue to call into question specifically what levels are categorized as deficient. The World Health Organization defined a deficiency as a 25(OH) vitamin D concentration of 10 ng/mL or less, and insufficiency as 20 ng/mL or less<sup>20</sup>. The American Institute of Medicine defines deficiency as a level of 12 ng/mL or less, and 20 ng/mL as normal<sup>21</sup>. Typically, most experts define vitamin D deficiency as less than 20 ng/mL of serum 25(OH) vitamin D and relative insufficiency between 21 to 29 ng/mL with normal levels greater than 30 ng/mL<sup>8,22-27</sup>. The ideal serum level of vitamin D has been determined as a one sufficient to maintain parathyroid hormone (PTH) within a normal range as vitamin D deficiency can cause secondary hyperparathyroidism. Though plateau levels of PTH can

Table 2. Subgroup Analysis of Vitamin D Level

Variable	No. of patients	Level of vitamin D (ng/mL)	P-value	
Sex	Female	530 (72.4)	12.8±8.4	0.505
	Male	202 (27.6)	13.2±7.3	
Age (yr)	60-69	84 (11.5)	14.2±7.9	0.151
	70-79	276 (37.7)	12.7±8.2	
	80-89	314 (42.9)	13.1±8.0	
	≥90	58 (7.9)	11.1±8.1	
Season	Spring	175 (23.9)	11.3±7.3	0.017
	Summer	162 (22.1)	14.5±8.4	
	Fall	193 (26.4)	13.7±8.2	
	Winter	202 (27.6)	12.5±8.2	
Diagnosis	Neck fracture	342 (46.7)	12.2±7.6	0.027
	Trochanter fracture	390 (53.3)	13.5±8.5	
Ambulation	Koval I, II	545 (74.5)	13.1±8.3	0.405
	Koval III, IV	157 (21.4)	12.2±7.2	
	Koval V, VI	30 (4.1)	13.0±8.9	
Residence	House	610 (83.3)	13.1±8.2	0.348
	Nursing home	72 (9.8)	12.6±7.9	
	Nursing hospital	50 (6.8)	11.4±6.9	

Values are presented as number (%) or mean±standard deviation.

be reached at various serum levels of 25(OH) vitamin D, in general, plateau levels are found when vitamin D is more than 30 ng/mL<sup>26-29</sup>). Given these findings, the current study adopted the criteria recognized by most experts, defining sufficient or normal levels of 25(OH) vitamin D as more than 30 ng/mL.

The current study found that vitamin D deficiency (<20 ng/mL) was present in 83.2% of patients, with 11.9% categorized as insufficient (20-29.9 ng/mL), and only 4.9% met the criteria of sufficient vitamin D level of more than 30 ng/mL. The percentage of patients with vitamin D deficiency in the present study was higher when compared to other studies<sup>13-17</sup>). In the current study, the average vitamin D concentration of males and females was 13.2 ng/mL and 12.8 ng/mL, respectively. Park et al.<sup>30</sup> reported an average vitamin D concentration in the general Korean population over 65 years old of 20 ng/mL in men and 18.3 ng/mL in women. Similar to the current study, patients with hip fractures were found to have a greater vitamin D deficiency.

Hip fracture is the most catastrophic consequence of osteoporosis due to the high morbidity and mortality rates associated with this type of fracture. The ultimate goal of osteoporosis treatment is prevention of fracture. Vitamin D and fracture risk reduction were not relevant in meta-analysis without considering vitamin D dose<sup>31</sup>), but in a recent meta-analysis, high-dose vitamin D supplementation ( $\geq$  800 international unit [IU] daily) was somewhat favorable in the prevention of hip fracture and any non-vertebral fracture in persons 65 years of age or older<sup>32</sup>). A similar meta-analysis found that a daily low dose of 400 IU vitamin D may not be clinically effective in preventing falls in the elderly whereas a high dose of 800 IU vitamin D plus calcium was associated with a lower risk of falling<sup>8</sup>). The Korean Society for Bone and Mineral Research recommends that a blood 25(OH) D concentration should be at least 20 ng/mL to prevent osteoporosis and 30 ng/mL or more may be needed to treat osteoporosis and prevent falls in osteoporosis patients<sup>33</sup>).

In the subgroup analysis, vitamin D concentration in summer was significantly higher than in other seasons. Although there have been reports of decreased vitamin D synthesis in the skin with age<sup>34</sup>), our results indicate that sunlight exposure is one of the most important factors to maintain adequate vitamin D levels, even in older adults in agreement with many other studies<sup>13-16</sup>). As the patient's sunlight exposure could not be measured directly, it was confirmed indirectly using the Koval score, though our results did not show a significant relationship between Koval score and

vitamin D concentration. Other variables such as age, sex, and residence were not associated with vitamin D deficiency. Vitamin D levels were significantly higher in patients with trochanter fractures than in patients with femur neck fractures, but no clear reason for this relationship was apparent.

Important sources of vitamin D are sunlight exposure and vitamin D intake through diet and supplements. Vitamin D-fortified foods are not common in Korea, therefore sunlight exposure and vitamin D supplements are important for the maintenance of vitamin D concentration. Korea is located from 33° to 38° north latitude and has four distinct seasons. Additionally, most of Korean have a type IV skin according to Fitzpatrick classification<sup>35</sup>). There is no research on the specific solar exposure time to properly maintain vitamin D levels in the blood at these latitudes. However, based on studies conducted in other latitudes, an appropriate sun exposure time for the synthesis of 1,000 IU of vitamin D is around 10 minutes in the summer solstice, 40 minutes in the winter solstice, and approximately 15 minutes in the spring equinox at noon, with 25% exposure for individuals with type IV skin (based on Fitzpatrick classification) which is most common in Korea<sup>36</sup>).

The current study had some limitations. We were unable to determine if patients took vitamin D supplements or not before admission which may have influenced blood levels. An additional limitation is the lack of an agreed-upon level for vitamin D deficiency worldwide, impacting reports of the prevalence of vitamin D deficiency and insufficiency based on how the cutoff value was determined. Finally, circulatory fluctuation, diet, kidney, liver disease, or other diseases that could affect vitamin D levels were not considered in this study. Despite these limitations, this study is the largest to date on the prevalence of vitamin D deficiency in elderly hip fracture patients in Korea playing an important role in the treatment of patients at this population in the future.

## CONCLUSION

Vitamin D deficiency and inadequacy were high in Korean patients with low-energy hip fractures in and only 4.9% of patients showed normal blood vitamin D levels. Efforts to maintain adequate levels of vitamin D in the blood through proper sun exposure and vitamin D supplements are needed in patients at risk of hip fractures in Korean populations.

## CONFLICT OF INTEREST

The authors declare that there is no potential conflict of interest relevant to this article.

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