Prevalence of Low Vitamin D Levels in Patients With Orthopedic Trauma

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Abstract

Low levels of serum vitamin D have been linked to numerous musculoskeletal and nonmusculoskeletal conditions. Vitamin D deficiency appears relatively high among various patient subpopulations, including patients with fracture nonunion.

We conducted a retrospective study to determine the prevalence of vitamin D deficiency and insufficiency in a large population of patients with orthopedic trauma. The study included all patients who were over age 18 years, had no risk factors for vitamin D deficiency, and were treated for an acute fracture at a Level 1 trauma center. Between January 2009 and September 2010, 889 trauma patients had recorded serum 25-hydroxyvitamin D levels.

Overall prevalence of combined vitamin D deficiency/insufficiency was 77%; prevalence of vitamin D deficiency alone was 39%. There were no statistically significant ($P < .05$) age or sex differences among the population. There did not appear to be a seasonal difference.

Vitamin D deficiency and insufficiency in acute orthopedic trauma patients appear very common. Further investigation is needed to fully understand the clinical significance.

The role of vitamin D in general health maintenance is a topic of increasing interest and importance in the medical community. Not only has vitamin D deficiency been linked to a myriad of nonorthopedic maladies, including cancer, diabetes, and cardiovascular disease, but it has demonstrated an adverse effect on musculoskeletal health.[1] Authors have found a correlation between vitamin D deficiency and muscle weakness, fragility fractures, and, most recently, fracture nonunion.[1] Despite the detrimental effects of vitamin D deficiency on musculoskeletal and general health, evidence exists that vitamin D deficiency is surprisingly prevalent.[2] This deficiency is known to be associated with increasing age, but recent studies have also found alarming rates of deficiency in younger populations.[3,4]

Although there has been some discussion regarding optimal serum levels of 25-hydroxyvitamin D, most experts have defined vitamin D deficiency as a 25-hydroxyvitamin D level of 20 ng/mL or less and insufficiency as 21 to 32 ng/mL.[5] Hollis and Wagner[5] found increased serum parathyroid hormone and bone resorption and impaired dietary absorption of calcium when 25-hydroxyvitamin D levels were under 32 ng/mL. Given these data, a 25-hydroxyvitamin D level of 21 to 32 ng/mL (52-72 nmol/L) can be considered as indicating a relative insufficiency of vitamin D, and a level of 20 ng/mL or less can be considered as indicating vitamin D deficiency.

Vitamin D plays a vital role in bone metabolism and has been implicated in increased fracture risk and in fracture healing ability. Therefore, documenting the prevalence of vitamin D deficiency in patients with trauma is the first step in raising awareness among orthopedic traumatologists and further developing a screening-and-treatment strategy for vitamin D deficiency in these patients. Steele and colleagues[6] retrospectively studied 44 patients with high- and low-energy fractures and found an almost 60% prevalence of vitamin D insufficiency. If vitamin D insufficiency is this prevalent, treatment

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protocols for patients with fractures may require modifications that include routine screening and treatment for low vitamin D levels.

After noting a regular occurrence of hypovitaminosis D in our patient population (independent of age, sex, or medical comorbidities), we conducted a study to determine the prevalence of vitamin D deficiency in a large orthopedic trauma population.

Patients and Methods

After obtaining Institutional Review Board approval for this study, we retrospectively reviewed the charts of all patients with a fracture treated by 1 of 4 orthopedic traumatologists within a 21-month period (January 1, 2009 to September 30, 2010). Acute fracture and recorded 25-hydroxyvitamin D level were the primary criteria for study inclusion. Given the concern about vitamin D deficiency, it became common protocol to check the serum 25-hydroxyvitamin D levels of patients with acute fractures during the review period. Exclusion criteria were age under 18 years and presence of vitamin D deficiency risk factors, including renal insufficiency (creatinine level, ≥2 mg/dL), malabsorption, gastrectomy, active liver disease, acute myocardial infarction, alcoholism, anorexia nervosa, and steroid dependency.

During the period studied, 1830 patients over age 18 years were treated by 4 fellowship-trained orthopedic traumatologists. Of these patients, 889 (487 female, 402 male) met the inclusion criteria. Mean age was 53.8 years. Demographic data (age, sex, race, independent living status, comorbid medical conditions, medications) were collected from the patients' medical records. Clinical data collected were mechanism of injury, fracture location and type, injury date, surgery date and surgical procedure performed (when applicable), and serum 25-hydroxyvitamin D levels.

Statistical Methods

Descriptive statistics (mean, median, mode) were calculated. The χ^2 test was used when all cell frequencies were more than 5, and the Fisher exact probability test was used when any cell frequency was 5 or less. Prevalence of vitamin D deficiency and insufficiency was calculated in multiple patient populations. Patients were analyzed according to age and sex subgroups.

Definitions

Vitamin D deficiency was defined as a serum 25-hydroxyvitamin D level of 20 ng/mL or less and insufficiency as 21 to 32 ng/mL.[2] As the serum test was performed independent of the investigators and with use of standard medical laboratory protocols and techniques, there should be no bias in the results. We had intended to have all patients undergo

Table 1. **Prevalence of Vitamin D Deficiency and Insufficiency**

Sex	Deficiency, %	Insufficiency/Deficiency, %
Female	40.04	75.77
Male	37.81	79.35
Overall	39.03	77.39

Table 2. **Prevalence of Vitamin D Deficiency and Insufficiency by Age Group**

	n				%	
Age Group, y	Deficiency	Deficiency/ Insufficiency	Normal	Total	Deficiency	Insufficiency
18-25	25	47	39	86	29.07	54.65
26-35	43	100	26	126	34.13	79.37
36-45	45	74	17	91	49.45	81.32
46-55	86	151	34	185	46.49	81.62
56-65	62	128	29	157	39.49	81.53
66-75	33	71	19	90	36.67	78.89
76+	53	117	37	154	34.42	75.97
Total	347	688	201	889	39.03	77.39

Table 3. **Prevalence of Vitamin D Deficiency and Insufficiency in Women**

	n				%	
Age Group, y	Deficiency	Deficiency/ Insufficiency	Normal	Total	Deficiency	Insufficiency
18-25	6	10	14	24	25.00	41.67
26-35	19	43	10	53	35.85	81.13
36-45	25	37	9	46	54.35	80.43
46-55	42	74	19	93	45.16	79.57
56-65	36	70	18	88	40.91	79.55
66-75	22	42	16	58	37.93	72.41
76+	45	93	32	125	36.00	74.40
Total	195	369	118	487	40.04	75.77

Table 4. **Prevalence of Vitamin D Deficiency and Insufficiency in Men**

	n				%	
Age Group, y	Deficiency	Deficiency/ Insufficiency	Normal	Total	Deficiency	Insufficiency
18-25	19	37	25	62	30.65	59.68
26-35	24	57	16	73	32.88	78.08
36-45	20	37	8	45	44.44	82.22
46-55	44	77	15	92	47.83	83.70
56-65	26	58	11	69	37.68	84.06
66-75	11	29	3	32	34.38	90.63
76+	8	24	5	29	27.59	82.76
Total	152	319	83	402	37.81	79.35

serum testing during the review period because that was our usual protocol. However, test results were available for only 889 (49%) of the 1830 patients with orthopedic trauma during the review period. Although a false-positive is theoretically possible, this series of orthopedic trauma patients is the largest in the literature and therefore should be more accurate than the previously reported small series.

Results

There were no significant ($P < .05$) age or sex differences in prevalence of vitamin D deficiency or insufficiency in our patient population. Overall prevalence of deficiency/insufficiency was 77.39%, and prevalence of deficiency alone was 39.03% (**Table 1**). Overall, patients in the 18- to 25-year age group had the lowest prevalence of deficiency (29.1%; $P = .25$) and insufficiency (54.7%; $P = .08$). Patients in the 36- to 65-year age group had a higher prevalence of deficiency and insufficiency, but neither difference was statistically significant. **Table 2** lists prevalence of deficiency and insufficiency by age group.

Women in the 18- to 25-year age group had a lower prevalence of deficiency (25%; $P = .41$) and insufficiency (41.7%; $P = .16$) than women in the other age groups (**Table 3**). Men in the 18- to 25-year age group had a lower prevalence of insufficiency (59.7%; $P = .24$) than men in the other age groups (**Table 4**). There were no other remarkable age or sex differences in prevalence of deficiency or insufficiency. There did not appear to be any

seasonal effect based on injury date and serum 25-hydroxyvitamin D level.

Discussion

We conducted this study to determine the prevalence of vitamin D deficiency in a large population of patients with orthopedic trauma. Results showed that vitamin D deficiency and insufficiency were prevalent in this population, which to our knowledge is the largest studied for vitamin D deficiency. In a 6-month study of 44 fractures, Steele and colleagues[6] found an overall 60% rate of deficiency/insufficiency. Although their investigation is important—it was the first of its kind to evaluate patients with various fracture types, including those with high-energy causes—its numbers were small, and the period evaluated (June 1, 2006 to February 1, 2007) was short (8 months). Use of that time frame may have led to an underestimate of the prevalence of vitamin D deficiency, as vitamin D levels are higher in late summer because of increased sun exposure. Our study of 889 patients over 21 months allowed for seasonal variability of vitamin D levels. We did not notice a specific difference in patients who were treated during winter vs summer. Furthermore, our 77% prevalence of vitamin D insufficiency and 39% prevalence of vitamin D deficiency indicate how widespread low vitamin D levels are in a large Midwestern orthopedic trauma population. In the Pacific Northwest, Bee and colleagues[7] studied seasonal differences in patients with surgically treated fractures and found an average difference of 3 ng/mL between winter and summer serum levels. However, the real issue, which should not be overlooked, is that the average 25-hydroxyvitamin D level was under 30 ng/mL in both cohorts (26.4 ng/mL in winter vs 29.8 ng/mL in summer). The emphasis should be that both levels were insufficient and that seasonal variance does not really change prevalence.

With use of the current definitions, it has been estimated that 1 billion people worldwide have vitamin D deficiency or insufficiency, with the elderly and certain ethnic populations at higher risk.[8-10] Vitamin D deficiency is a common diagnosis among elderly patients with hip fractures. According to various reports, 60% to 90% of patients treated for hip fractures are deficient or insufficient in vitamin D.[8,9] Hypovitaminosis D has also been noted in medical inpatients with and without risks for this deficiency.[2] Surprisingly, low vitamin D levels are not isolated to the elderly. In Massachusetts, Gordon and colleagues[11] found a 52% prevalence of vitamin D deficiency in Hispanic and black adolescents. Nesby-O'Dell and colleagues[10] found that 42% of 15- to 49-year-old black women in the United States had vitamin D deficiency at the end of winter. Bogunovic and colleagues[12] noted 5.5 times higher risk of low vitamin D levels in patients with darker skin tones. Although vitamin D deficiency has been linked to specific races, it frequently occurs in lower-risk populations as well. Sullivan and colleagues[4] found a 48% prevalence of vitamin D deficiency in white preadolescent girls in Maine. Tangpricha and colleagues[3] reported a 32% prevalence of vitamin D deficiency in otherwise fit healthcare providers sampled at a Boston hospital. Bogunovic and colleagues[12] also showed that patients between ages 18 years and 50 years, and men, were more likely to have low vitamin D levels.

Establishing the prevalence of hypovitaminosis D in orthopedic trauma patients is needed in order to raise awareness of the disease and modify screening and treatment protocols. Brinker and O'Connor[13] found vitamin D deficiency in 68% of patients with fracture nonunions, which suggests that hypovitaminosis D may partly account for difficulty in achieving fracture union. Bogunovic and colleagues[12] found vitamin D insufficiency in 43% of 723 patients who underwent orthopedic surgery. Isolating the 121 patients on the trauma service revealed a 66% prevalence of low vitamin D levels. Our 77% prevalence of low vitamin D levels in 889 patients adds to the evidence that low levels are common in patients with orthopedic trauma. Understanding the importance of vitamin D deficiency can be significant in reducing the risk of complications, including delayed unions and nonunions, associated with treating orthopedic trauma cases.

Although our study indicates an alarming prevalence of insufficient vitamin D levels in our patient population, it does not provide a cause-and-effect link between low serum 25-hydroxyvitamin D levels and risk of fracture or nonunion. However, further investigations may yield clinically relevant data linking hypovitaminosis D with fracture risk. Although we did not include patients with nonunion in this study, new prospective investigations will address nonunions and subgroup analysis of race, fracture type, management type (surgical vs nonsurgical), injury date (to determine seasonal effect), and different treatment regimens.

The primary limitation of this study was its retrospective design. In addition, though we collected vitamin D data from 889 patients with acute fracture, our serum collection protocols were not

standardized. Most patients who were admitted during initial orthopedic consultation in the emergency department had serum 25-hydroxyvitamin D levels drawn during their hospital stay, and patients initially treated in an ambulatory setting may not have had serum vitamin D levels drawn for up to 2 weeks after injury (the significance of this delay is unknown). Furthermore, the serum result rate for the overall orthopedic trauma population during the review period was only 49%, which could indicate selection bias. There are multiple explanations for the low rate. As with any new protocol or method, it takes time for the order to become standard practice; in the early stages, individuals can forget to ask for the test. In addition, during the review period, the serum test was also relatively new at our facility, and it was a "send-out" test, which could partly account for the lack of consistency. For example, some specimens were lost, and, in a number of other cases, excluded patients mistakenly had their 1,25-hydroxyvitamin D levels measured and were not comparable to included patients. Nevertheless, our sample of 889 patients with acute fractures remains the largest (by several hundred) reported in the literature.

From a practical standpoint, the present results were useful in updating our treatment protocols. Now we typically treat patients only prophylactically, with 50,000 units of vitamin D_2 for 8 weeks and daily vitamin D_3 and calcium until fracture healing. Patients are encouraged to continue daily vitamin D and calcium supplementation after fracture healing to maintain bone health. Compliance, however, remains a continued challenge and lack thereof can potentially explain the confusing effect of a supplementation protocol on the serum 25-hydroxyvitamin D level.[14] The only patients who are not given prophylactic treatment are those who previously had been denied it (patients with chronic kidney disease or elevated blood calcium levels).

Vitamin D deficiency and insufficiency are prevalent in patients with orthopedic trauma. Studies are needed to further elucidate the relationship between low vitamin D levels and risk of complications. Retrospectively, without compliance monitoring, we have not seen a direct correlation with fracture complications.[15] Our goal here was to increase orthopedic surgeons' awareness of the problem and of the need to consider addressing low serum vitamin D levels. The treatment is low cost and low risk. The ultimate goal—if there is a prospective direct correlation between low serum vitamin D levels and complications—is to develop treatment strategies that can effectively lower the prevalence of low vitamin D levels.

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