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ORIGINAL ARTICLE

Plasma 25-Hydroxyvitamin D Levels in Operative Patella Fractures

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Abstract *Background:* Patella fractures have not traditionally been considered "fragility" fractures. *Questions/Purpose:* The purpose of this study was to examine the demographic patterns (age and gender distribution) and plasma 25-hydroxyvitamin D levels of a cohort of patients with operative patella fractures. *Patients and Methods:* Medical records were reviewed on all consecutive patients presenting to our institution with operative patella fractures from 2003 to 2009. Seventy-eight operative patella fractures (25 male, 53 female) were identified with a mean age of 58 years (range, 22–89 years). *Results:* The majority of patients with patella fractures in this series were females over the age of 50 years who sustained low-energy falls from a standing height or less. Twenty-four patients (80%) had vitamin D insufficiency or deficiency at the time of injury. For 68 patients (87%), the patella fracture represented their first fracture. Patients with known osteoporosis risk factors did not have higher rates of vitamin D insufficiency/deficiency. *Conclusions:* The age and gender distribution, as well as the prevalence of vitamin D insufficiency/deficiency, of operative patella fractures, suggest that these patients likely have abnormal vitamin D levels and should undergo a metabolic bone work-up.

Keywords patella fracture · osteoporosis · vitamin D · fragility fracture · metabolic bone disease

Level of Evidence: Level IV: Prognostic Study.

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Introduction

Osteoporosis is a skeletal disorder characterized by impaired bone strength that increases risk of fracture. In fact, it is considered by some to be a "silent" disease until a fracture occurs [14]. Among Caucasian women over age 50 years, approximately 40% will experience a hip, spine, or wrist fracture during the remainder of their lives [7]. With a rising incidence of osteoporotic fractures associated with an increasing elderly population, one can expect that the burden of the morbidity and mortality associated with future fractures will continue to expand [1, 8]. It is therefore critical that these "fragility" fractures be recognized and early treatment instituted to reduce the risk of future fractures, particularly of the hip and vertebrae [3, 10, 13]. According to the World Health Organization, a fragility fracture is that which occurs in a postmenopausal woman or man age 50 years or older with low bone mass (T score of −2.5 or less at the femoral neck, total hip, lumbar spine, or one third radius, as measured by dual-energy X-ray absorptiometry) [10, 20]. It is not surprising that numerous observational studies have linked low levels of 25-hydroxyvitamin D to "fragility" fractures, emphasizing the critical role vitamin D plays in skeletal mineralization [12, 19]. Accordingly, vitamin D has been implicated in fracture healing, with a high incidence of vitamin D deficiency found in patients with fracture nonunions [2]. Because of this, vitamin D has received much attention from physicians recently as a means of treatment to reduce the growing morbidity and mortality associated with future osteoporotic fractures and promoting their healing [1, 8]. However, to be effective in preventing future

osteoporotic fractures and to maximize the healing potential of fractures in osteoporotic patients, it is critical to recognize a "fragility" fracture early on, preferably at the time of injury. Traditionally, fractures of the hip, vertebrae, forearm, humerus, ribs, tibia, and pelvis have been regarded as potentially osteoporotic fractures, while fractures of the ankle, hands, feet, skull, face, and patella have not [16, 17, 20]. Despite the patella being recognized as a site for assessing bone quality in osteoporotic patients via ultrasound transmissions [18], fractures of the patella have not previously received widespread attention as potential "fragility" fractures. In one study, patella fractures accounted for only 0.3% of sentinel fractures in women with osteoporosis [17].

The purpose of this study, therefore, was to examine and define the demographic characteristics of a consecutive cohort of patients who underwent operative treatment for patella fractures. A secondary aim of this study included an assessment of plasma 25-hydroxyvitamin D levels in these patients. Finally, we also sought to document the presence or absence of risk factors for osteoporosis or other metabolic bone diseases in these patients

Materials and Methods

Operative records of a single trauma fellowship-trained orthopedic surgeon were reviewed to identify patients who underwent open reduction internal fixation of a patella fracture between 2003 and 2009. All consecutive patients with unilateral operative patella fractures were considered for inclusion in this study. Patients with bilateral patella fractures were excluded (n=1). Patients who were on vitamin D therapy prior to their patella fracture were excluded as well (n=13). The study protocol was approved by the Institutional Review Board.

Ninety-three operative patella fractures were initially identified, with 78 fractures in 78 patients meeting our inclusion and exclusion criteria for participation in this study. The study population, therefore, consisted of 25 males and 53 females (female/male ratio of 2.12:1), with an overall mean age at the time of injury of 58 years (range, 22–89 years). The electronic medical records and hard copy office charts of the included patients were reviewed for demographic and laboratory data. Demographic data collected consisted of patient age, gender, height, and weight. The body mass index (BMI) [6] of each patient was calculated from their height and weight (Table 1). The mechanism of injury was determined for each patient and divided into a binary variable of "high energy" or "low energy", based on whether the mechanism involved greater or less energy than a fall from a standing height, respectively. All falls from a standing height in this cohort were falls that occurred forward onto a flexed knee. Patient history pertaining to prior "fragility" fractures, a previous known diagnosis of osteoporosis, or regular use of osteoporotic medications was recorded. Risk factors for poor bone quality, specifically antiestrogen therapy, prednisone (>7.5 mg/day [or equivalent] for ≥6 months), and alcohol use were noted for each patient as well [9].

Table 1 Mean patient height, weight, and BMI according to gender (expressed as means±standard deviations)

	Height (m)	Weight (kg)	BMI (kg/m^2)
Male patients (n=17)	1.77±0.10	87.0±25.8	27.6±6.20
Female patients (n=49)	1.64±0.09	64.5±10.1	24.1±4.46
All patients (n=66)	2.0±0.11	72±19.8	25.2±5.31

For 30 patients in this series, plasma 25-hydroxyvitamin D levels (in nanograms per milliliter) were available and recorded. During the first part of the study period, 25-hydroxyvitamin D levels were not routinely obtained on patients with patella fractures at our institution. The vitamin D level was analyzed using a quantitative chemiluminescent immunoassay (ARUP Laboratories, Salt Lake City, UT, USA). Vitamin D levels were stratified into three categories: normal (greater than or equal to 30 ng/mL), insufficiency (between 20 ng/mL and 29 ng/mL), and deficiency (less than 20 ng/mL) [5].

Descriptive statistics were calculated for variables of interest. Continuous variables were represented by means and standard deviations or medians and ranges, while frequencies and percentages were reported for categorical and binary outcome variables. Fisher's exact test or the nonparametric Wilcoxon ranksum test was used to evaluate binary and categorical variables. A p value of <0.05 was considered to be statistically significant. All analyses were conducted using SAS software version 9.1 (SAS Institute, Cary, NC, USA).

Results

In this series of patients, at the time of injury, most were female over the age of 50 years. Seventy-one percent (n=55) of the patients were older than age 50 years; and of those patients, 79% (42/55) were female. On the other hand, only 52% of the male patients (13/25) were older than age 50 years at the time of their injury. On average, patients in this series were not obese with a mean BMI of 25.2±5.31 (Table 1). Seventy-two patients (92%) sustained "low-energy" injuries, defined as a fall from a standing height onto a flexed knee, or less. All but one female in this cohort, as well as 80% (20/25) of the male patients, had operative patella fractures associated with "low-energy" injuries. Six patients (five male, one female) sustained "high-energy" injuries from the following mechanisms: pedestrian stuck by motor vehicle (n=3), fall from greater than standing height (n=2), and motorcycle accident (n=1). The mean age of patients with "high-energy" fractures was 33 years (range, 23–47 years).

The majority of patients in this series demonstrated vitamin D insufficiency (47%) or deficiency (33%) at the time of injury (Fig. 1). In the 30 patients (six males, 24 females) where plasma 25-hydroxyvitamin D was measured, the mean overall level was 24.1±8.71 ng/mL. For female patients, the mean 25-hydroxyvitamin D level was 24.8±8.76 ng/mL; for males, it was 21.0±8.51 ng/mL. Twenty-four of these patients (80%) demonstrated vitamin D insufficiency (47%) or deficiency (33%) at the time of injury.

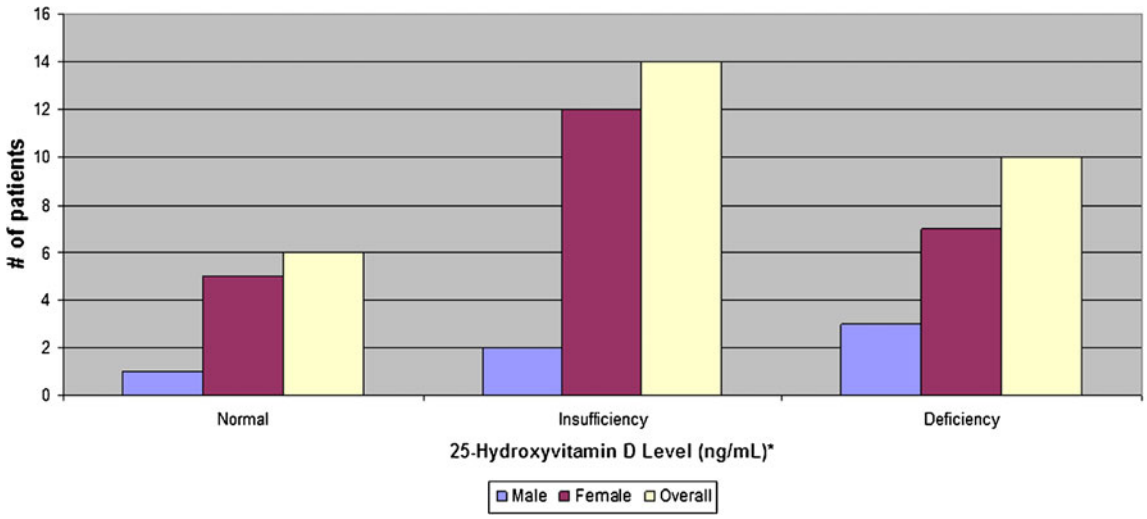

Fig. 1. 25-Hydroxyvitamin D levels in patients with operative patella fractures. *25-hydroxyvitamin D levels defined as normal (≥30 ng/mL), insufficiency (between 20 ng/mL and 29 ng/mL), or deficiency (<20 ng/mL).

The majority of the patients in this series did not have a prior history of a metabolic bone disease and for 68 patients (87%) the patella fracture represented their first fracture. Ten patients (13%) reported having at least one prior "fragility" fracture during their lifetime. Eight of those patients had distal radius fractures prior to their patella fracture and two patients had prior hip fractures. Fourteen patients (18%) had a known diagnosis of osteoporosis or osteopenia prior to their patella fracture, and all but one of these patients were female. All but one of the male patients had not had a prior metabolic bone disease diagnosis of any kind. Other pertinent osteoporosis risk factors included excess alcohol intake (greater than one drink per day) in four patients (5%), antiestrogen therapy in three patients (4%), and chronic prednisone therapy in two patients (3%). Patients with the above known risk factors were not statistically more likely to have abnormal vitamin D levels than those patients who had no known prior risk factors ($p>0.05$).

Discussion

Traditionally, fractures of the distal radius, vertebrae, and hip have been regarded as osteoporotic fractures [17] and would typically lead to a metabolic bone evaluation at our institution. Patella fractures, on the other hand, have not been previously characterized in the literature as "fragility" fractures nor had they been considered as such at our institution prior to this study. The emergency room is becoming recognized as a setting whereby certain fractures can be recognized as harbingers of underlying osteoporosis and lead to the initiation of a metabolic bone evaluation in those patients [4]. At our institution, as shown in this cohort of patients, we have seen a preponderance of operative patella fractures in the emergency room that occurred in women over the age of 50 years, many of which were highly comminuted on CT scans (not reported here) despite their low-energy mechanisms of injury. The patella fractures in men were also predominantly from low-energy mechanisms (80% of males). Because of these age and gender patterns, as well as fracture characteristics, we began obtaining 25-hydroxyvitamin D levels routinely on patients with operative patella fractures. The incidence of vitamin D insufficiency or deficiency that we found in the cohort of patients presented here was 80% (47% insufficient, 33% deficient).

To our knowledge, prior reports on vitamin D levels in patients with operative patella fractures are not available for comparison. However, literature regarding vitamin D levels in other "fragility" fractures is worth comparing to our results. In our series, 33% of patients had vitamin D deficiency (<20 ng/mL) at the time of injury. This is similar to values reported on acute hip fractures in women. In 2004, Nuti et al. found that 35.1% of 74 women with acute hip fractures had 25-hydroxyvitamin D levels below 20 ng/mL [15]. Furthermore, even more profound was that hypovitaminosis D was shown in a study in JAMA in 1999 where 50% of postmenopausal US women with acute hip fractures were found to be vitamin D deficient [11].

This study has several limitations worth further discussion. Due to its retrospective nature, it is subject to selection bias. Non-operative patella fractures were not included in this study due to difficulty with identifying and reliably capturing those patients because they are often not seen in the emergency room at our institution by an orthopedic trauma surgeon. This represents a potential source of selection bias for operative patella fractures and an opportunity for future studies to compare vitamin D levels to patients with non-operative patella fractures. Nonetheless, all consecutive operative patella fractures at our institution were considered for inclusion and only those not satisfying our inclusion/exclusion criteria were excluded. Also, 25-hydroxyvitamin D levels were not available for all patients in this study. This again pertains to the retrospective design whereby early patients in the study period did not undergo an assessment of their vitamin D level routinely. Furthermore, results of bone mineral density measurements were not available for this study, which would be necessary data to more definitely show that patella fractures are in fact

"fragility" fractures. We also do not have data on whether early treatment in these patients reduces the risk of future fractures. While these represent weaknesses of the study, they highlight these issues as possible topics for future studies. This study's greatest strength is that it is the first report in the literature to suggest that patella fractures, particularly in women over age 50 with a low-energy mechanism of injury, be considered as "fragility" fractures, and it is the first to report the prevalence of vitamin D insufficiency/deficiency in these patients.

For 87% of the patients in this study, the patella fracture represented their first fracture. Based on the demographic and laboratory results in this study, in our opinion, this represents a unique opportunity to evaluate these patients further for metabolic bone disease. Future studies are needed to determine if patients with low-energy patella fractures have low bone mineral densities and whether they would benefit from early treatment, including lifestyle changes (nutrition supplementation, activity modification, fall prevention), and/or antiresorptive or anabolic pharmacotherapeutics [7]. Nonetheless, we now routinely refer patients with low-energy operative patella fractures to a metabolic bone specialty clinic at our institution.

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Disclosures Each author certifies that he or she has no commercial associations (e.g., consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted article. One or more of the authors have or will receive monies from a commercial entity that may be perceived as a potential conflict of interest. One or more of the authors' institution has or will received monies from a commercial entity that may be perceived as a potential conflict of interest.

Each author certifies that his or her institution has approved the reporting of these cases, that all investigations were conducted in conformity with ethical principles of research.

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