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Assessing the Relationship Between 25-Hydroxy Vitamin D3 Deficiency with Forearm Fracture in 2 to 15 Year-Old Children

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Abstract

Objectives: Fractures are prevalent injuries in children. Forearm fractures include 25% of children fractures. Although low level of 25 (OH) vitamin D3 is related with less bone density and more risk of fractures due to osteoporosis in adults, not enough data are available on the relationship between decreased levels of 25 (OH) vitamin D3 and the risk of forearm fracture in children.

Methods: The current observational, analytic study included 30 children within the age range of 2 to 15 years with the verified fracture of both forearm bones. The recorded data included age, gender, the broken hand, and the educational status of parents. Moreover, the levels of serum 25-hydroxy vitamin D3, calcium, and phosphorus were measured in all subjects. The normal children (n = 54) without the history of fracture were considered as controls.

Results: The case group consisted of 21 males (70%) and 9 females (30%) and control group included 28 males (51.9%) and 26 females (48.1%). The mean age of the children with and without forearm fractures was 6.8 $\pm$ 3.17 and 6.96 $\pm$ 3.57 years, respectively. There were no significant differences between the groups in terms of gender, age, the broken hand, and father's education ($P > 0.05$). Serum 25 (OH) vitamin D3 level was 17.22 $\pm$ 13.42 ng/mL for the case group and 17.88 $\pm$ 11.21 ng/mL for the control group. These levels for serum calcium and phosphorus were 9.88 $\pm$ 0.44 and 5.02 $\pm$ 0.56 mg/dL for the cases, and 9.64 $\pm$ 0.44 and 4.72 $\pm$ 0.72 mg/dL for the controls, respectively ($P > 0.05$).

Conclusions: The results of the current study showed no relationship between the levels of serum vitamin D, calcium, and phosphorus as well as age, gender, broken hand, and parents' educational status and fracture of both bones of forearm. Larger studies with more variables are recommended.

Keywords: Forearm Fracture, Vitamin D Level, Calcium, Phosphorus, Children

1. Background

Radius and ulnar injuries are among the most prevalent reasons for orthopedic cares in children (1). There is an increasing risk of bone fractures both in males and females up to the age of 11 or 12 years, and then, reduces in females and increases in males (2). The males over 13 years have approximately twice bone fractures than the same age females (3-6). The children fractures are often ignored by physicians, whereas they have specific effect on daily activities and the risk of fractures in adulthood (7). Half of children have the experience of a bone fracture in childhood, and 40% of them have at least another fracture in rest of their lives (4). Radius and ulna fractures are the most prevalent types in children under 14 years (5). Radius shaft fracture is the third most prevalent bone fracture in kids after distal radius and humerus supracondylar fractures (8). The highest number of bone fractures occurs in 12-year females and 14-year males (3-6). This time period is immediately after rapid growth owing to puberty (6). Although there are public attempts to reduce the injuries in the children, various studies show increased incidence of forearm fractures in kids (9).

Evidence indicates that bone fractures and injuries are related with bone mineral level (10). Recent studies suggested that the decrease in the mineralization of bones related to environmental factors such as nutrition and physical inactivity in addition to genetic factors is correlated with improved risk of fractures in healthy children (11-16). More specifically, this issue is proposed about the fractures of forearm bones (12, 17).

Low levels of vitamin D lead to increased risk of fracture in neonates with rickettsia and adults with osteoporosis (10). Studies on the high-risk populations showed that children with vitamin D deficiency had less mineral bone density than their peers with normal levels of vitamin D (10). Nevertheless, the relationship between vitamin D levels and bone fractures in children is not fully assessed. The prevalence of vitamin D insufficiency or deficiency is ris-

ing in the world (18, 19). Recent studies in the Middle-East indicated that the prevalence of vitamin D deficiency is increasing in all age groups including children (20). It might be attributed to cultural reasons (21). Most of the vitamin D is produced in the skin by ultraviolet radiation and a small part is absorbed by the body via foodstuffs (22). Research studies showed an increasing risk of bone fractures in adults with lower levels of vitamin D; however, this relationship is not fully evaluated in children.

As the most prevalent cause of forearm fractures in children is trauma (3), and the main concentration is on the rapid management of the fracture, evaluating the predictable risk factors of osteoporosis such as vitamin D level, insufficient calcium intake, and physical inactivity (23) is usually forgotten. Thus, the current study aimed at measuring the serum levels of 25 (OH) vitamin D3, calcium, and phosphorus in children with fracture of both bones of forearm and comparing the results with the children in the control group.

2. Methods

The current study was conducted in accordance to the deceleration of Helsinki and approved by the ethical committee of Shahid Beheshti University of Medical Sciences. The current observational analytical study included the children within the age range of 2 to 15 years with the fracture of both forearm bones (radius and ulna) referred to Imam Hossein teaching Hospital affiliated to Shahid Beheshti University of Medical Sciences, Tehran, Iran. The exclusion criteria were the children with chronic disorders affecting bone density such as osteogenesis imperfect, rickettsia, and osteomalacia, children with underlying disorders who need to take corticosteroids or other drugs affecting bone density, and the children under treatment with vitamin D and calcium supplements. After signing the informed consent by the parents and the children, the demographic data including age, gender, the broken hand, and father and mother's educational status were recorded. Then, the levels of serum 25 OH vitamin D3, calcium, and phosphorus were measured. A total of 54 children with no history of chronic disease and fracture in the same age range were considered as the control group. They were the children who came to the clinical laboratory of hospital for routine check-ups, which included serum levels of calcium, phosphorus, and 25, OH vitamin D3. After signing the informed consent by their parents, the demographic data of the controls and also education level of their parents were recorded.

The data are presented as mean $\pm$ standard deviation (SD) and number (percent). The recorded data were analyzed with SPSS software version 21. The qualitative data were analyzed using Chi-square and the Mann-Whitney tests. The quantitative data were analyzed using t test. The data were first analyzed without any matching, and then, analyzed again after matching by age. P value < 0.05 was considered significant.

3. Results

Overall, 84 children aged 2 to 15 years were enrolled in the study; 30 cases (35.7%) had fracture of both bones of forearm and 54 healthy subjects (64.3%) were considered as the control. The demographic data of the subjects are presented in Table 1. A total of 21 children (70%) in the case group were male and 9 (30%) female. The number of males and females were 28 (51.9%) and 26 (48.1%), respectively in the control group. There was no statistically significant difference between the groups in terms of gender ($P > 0.05$). The mean age of the children with forearm fracture was 6.8 $\pm$ 3.17 years and the mean age for the controls was 6.96 $\pm$ 3.57 years ($P > 0.05$). Evaluation of the educational status of parents revealed that mothers of the control group were more educated than those of the case group ($P < 0.05$), but this difference was not observed in fathers' educational level (Table 1).

The serum levels of 25 (OH) vitamin D3, calcium, and phosphorus were measured in both groups. The mean levels of 25 (OH) vitamin D3 were 17.22 $\pm$ 13.42 and 17.88 $\pm$ 11.21 ng/mL in children with and without forearm fractures, respectively. Moreover, if the vitamin D level for each child was categorized into sufficient (> 20 ng/mL) and deficient (≤ 20 ng/mL), 24 cases (80%) and 33 controls (66.1%) had deficient levels of 25 (OH) vitamin D3. There was no significant difference in vitamin D levels between the 2 groups both in quantitative and qualitative classifications (Table 2; $P > 0.05$). Considering the cutoff value of 30 ng/mL for 25 (OH) vitamin D3 also showed no significant difference between the groups.

The mean serum calcium levels in the forearm fracture group was 9.88 $\pm$ 0.44 mg/dL and it was 9.64 $\pm$ 0.44 mg/dL in the control group ($P > 0.05$; Table 2). In addition, the mean serum phosphorus levels were 5.02 $\pm$ 0.56 and 4.72 $\pm$ 0.72 mg/dL for children with and without forearm fractures (group 1) and (group 2), respectively ($P > 0.05$).

The recorded data were also analyzed after matching the cases with the controls by the age. Overall, 27 cases were matched with 27 controls with same age. As presented in Table 3, considering 20 ng/mL as cutoff value for 25 (OH) vitamin D3, it was significantly more sufficient in the controls than cases. On the other hand, the mean level of phosphorus was higher in the control group than the cases, after matching. There was no other difference between the groups after matching by age.

Table 1. The Demographic Data of the Study Groups[a]

Parameter	Group 1 (with Fracture)	Group 2 (Without Fracture)	P Value
Gender			0.082
Male	21 (70)	28 (51.9)	
Female	9 (30)	26 (48.1)	
Age, y	6.80 ± 3.17	6.96 ± 3.57	0.836
Broken hand			-
Dominant	13 (43.3)	-	
Non-dominant	17 (56.7)	-	
Father's education			0.724
Under diploma	15 (20)	26 (48.1)	
Diploma	9 (30)	18 (33.3)	
AD	3 (10)	7 (13)	
BSc	3 (10)	2 (3.7)	
MSc	0	1 (1.9)	
Mother's education			0.014
Under diploma	14 (46.7)	35 (64.8)	
Diploma	16 (53.3)	12 (22.2)	
BSc	0	5 (9.3)	
MSc	0	2 (3.7)	

[a]Values are expressed as No. (%).

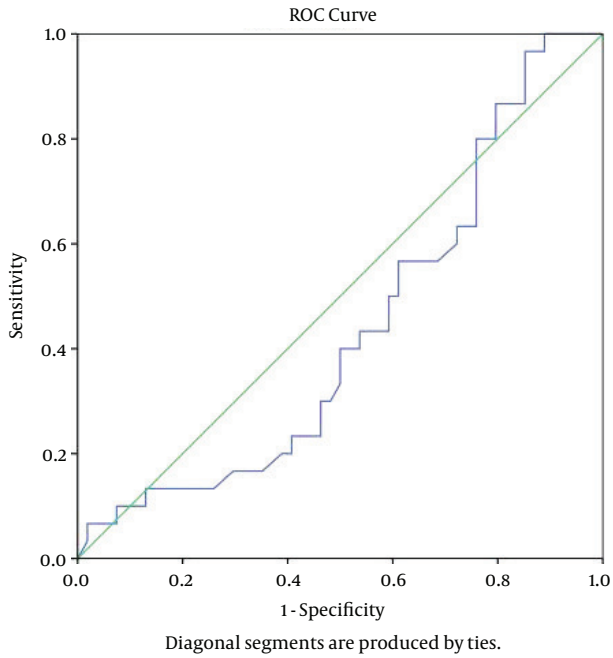

Figure 1. The ROC Curve to Calculate the Predictive Level of 25 (OH) Vitamin D3 for Fracture of Both Forearm Bones in Children Within the Age Range of 2 - 15 Years

The receiver operating characteristic (ROC) curve to calculate the cutoff value of 25 (OH) vitamin D3 to predict the fracture of both bones of forearm showed no significant results ($P > 0.05$); however, the highest value of specificity plus sensitivity was for 8.75 ng/mL level of 25 (OH) vitamin D3 with sensitivity of 96.7% and specify of 15% (Figure 1).

4. Discussion

The current study assessed the relationship of vitamin D, calcium, and phosphorus serum level with the prevalence of both forearm bones fracture and the results indicated no significant correlation between the 2 variables.

The main result of the current study was the high prevalence of vitamin D deficiency in both groups of children enrolled in the study (Table 2). It was reported that 30% to 50% of people worldwide have vitamin D-deficiency (24). The same prevalence of deficiency is also present in the Middle-East and Iran. In a study on 1210 persons within the age range of 20 to 65 years in Tehran, Iran, the prevalence of severe, moderate, and mild vitamin D deficiency was 9.5%, 57.6% and 14%, respectively, which was totally 81.3% (25). Another multi-center study on 5232 cases in various cities of Iran reported the prevalence of moderate to severe vitamin D deficiency of 45% in males and 41% in females (26).

The results of the current study on the possible risk factors of fracture of both forearm bones in children, such as age, gender, vitamin D, calcium, and phosphorus serum levels, parental educations and the broken hand showed no significant difference in terms of the considered risk factors between children with and without forearm fracture history. Worldwide studies reported various results, which were in accordance or contrast with the current study results.

The study by Ryan et al. evaluated the bone mineral density and vitamin D level in African-American children within the age range of 5 to 9 years with forearm fracture; 76 children with forearm fracture and 74 children without fracture. The results of this study, in accordance with those of the current study, showed no significant difference between the groups in terms of age, gender, parental educational status, the season of entering into the study, the duration of playing outside home, height, and calcium intake. Nevertheless, in contrast with the current study, the

Table 2. The Amounts of Measured Variables in the Enrolled Samples[a]

Variable	Group 1 (with Fracture)	Group 2 (Without Fracture)	P Value
Vitamin D, ng/mL	17.22 ± 13.42	17.88 ± 11.21	0.808
Vitamin D, 20 ng/mL Cutoff			0.092
Sufficient	6 (20)	21 (38.9)	
Deficient	24 (80)	33 (61.1)	
Vitamin D, 30 ng/mL Cutoff			0.59
Sufficient	2 (6.7)	3 (5.6)	
Deficient	28 (93.3)	51 (94.4)	
Ca, mg/dL	9.88 ± 0.84	9.64 ± 0.44	0.267
P, mg/dL	5.02 ± 0.56	4.72 ± 0.72	0.145

[a]Values are expressed as No. (%).

Table 3. The Amounts of Measured Variables in the Enrolled Samples After Matching by Age[a]

Variable	Group 1 (with Fracture)	Group 2 (Without Fracture)	P Value
Vitamin D, ng/mL	17.82 ± 14.02	22.58 ± 12.58	0.195
Vitamin D, 20 ng/mL Cutoff			0.006
Sufficient	6 (22.2)	16 (59.3)	
Deficient	21 (77.8)	11 (40.7)	
Vitamin D, 30 ng/mL Cutoff			0.642
Sufficient	2 (7.4)	3 (11.1)	
Deficient	25 (92.6)	51 (89.9)	
Ca, mg/dL	9.92 ± 0.85	9.62 ± 0.51	0.332
P, mg/dL	5.00 ± 0.53	4.45 ± 0.55	0.03

[a]Values are expressed as No. (%).

total Z score measured in bone densitometry, serum vitamin D level, and obesity were higher in children with forearm fracture (10).

In the study by Al-Daghri et al. on the level of 25 (OH) vitamin D3 in Saudi Arabian children, 234 cases with bone fracture and 1022 controls without bone fracture were enrolled. Their results showed that the levels of 25 (OH) vitamin D3 both in males and females with the history of bone fracture were less than that of the controls. Nevertheless, the levels of Vitamin D were low both in the case and control groups (20). This result was similar to the current study result that overall the levels of vitamin D are low in children with and without forearm fractures.

Moreover, Known et al., conducted a study in Australia on the prevalence of vitamin D deficiency in 2- to 17-year-old children (163 cases) referred to hospital for acute bone fracture. The risk factors for vitamin D deficiency such as skin pigmentation, the time period out of home and using sunscreen as well as anthropometric data including height, weight, puberty level, and body mass index (BMI) were assessed. The serum level of vitamin D was measured in cases and the levels less than 50 nmol/L were considered as deficiency. The results in this study showed than 82% of the enrolled children had at least 1 vitamin D deficiency risk factor. Overall, 57 children (35%) had vitamin D levels less than 50 nmol/L, which 45 cases had moderate deficiency (30 to 50 nmol/L) and 11 cases had mild deficiency (12.5 to 19 nmol/L); according to these results, measuring the level of vitamin D is recommended for all children who refer to hospitals with bone fracture (23).

The most important limitation of the study was the small sample size and limited number of evaluated variables to predict both forearm bones fracture in children. Therefore, future multi-center studies with larger samples are recommended.

4.1. Conclusion

The results of the current study revealed high prevalence of vitamin D deficiency in children with or without bone fractures. Age, gender, serum levels of vitamin D, calcium and phosphorus, the parental educational level, and dominancy or non-dominancy of broken limb do not have the capability to predict the probability of forearm bone fractures in children.

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