Original Clinical Article

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Prevalence of vitamin D insufficiency in children with forearm fractures

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Abstract

Purpose This study aimed to determine whether children with distal radius impaction fractures have increased prevalence of 25-hydroxyvitamin D (25(OH) D) insufficiency compared with healthy controls.

Patients and Methods This is a prospective controlled study. The 30 children who were diagnosed with forearm fracture at the orthopaedic emergency clinic were included in the study and 30 healthy children from the routine paediatric outpatient unit were included as the control group. Peripheric venous 25(OH) D, calcium (Ca), magnesium (Mg), phosphor (P), alkaline phosphatase (ALP) and parathyroid hormone (PTH) of both groups were recorded.
The sample size was estimated based on the effect size for a type I error of 5% and power of 80%.

Results Demographic characteristics of the two groups did not differ in terms of weekly physical activity levels and breast milk intake. The mean whole body BMI was similar in both groups of patients. History of previous fracture and 25(OH) D level were significantly lower in the patient group than the control group.

Conclusion In the present study, the prevalence of vitamin D insufficiency or deficiency was higher in patients with forearm impaction type fractures than healthy controls and the baseline levels reported in the literature. In addition, there were no significant differences in serum Ca, Mg, P, ALP and PTH levels between the healthy controls and the patient group.

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Keywords: vitamin D; forearm fracture; radius fracture; bone development

Introduction

In adults, forearm fractures are associated with lower bone mineral density, and are reported to be associated with future osteoporosis.[1-3] Factors associated with forearm fracture risk include low dietary calcium, low dietary milk intake and high body mass index (BMI).[3] Dietary risk factors, such as low calcium and milk intake, are more prevalent in lower socioeconomic regions.[4] Investigation of the relationship between non-displaced impaction type forearm fractures in children and both vitamin D deficiency and blood mineral count (calcium (Ca), magnesium (Mg), and phosphor (P)) has not been done yet in the current literature.

A typical serum 25-hydroxyvitamin D (25(OH) D) concentration for the borderline between deficiency and insufficiency is 20 ng/mL. There is much greater debate regarding the borderline between insufficiency and sufficiency, with values in the range of 20 to 29 ng/mL being suggested.[5]

Our aim was to determine whether children with distal radius impaction fractures have increased prevalence of 25(OH) D insufficiency compared with healthy controls. We hypothesised that children with forearm fractures would have significantly lower vitamin D levels.

Patients and methods

This is an IRB-approved prospective review of non-displaced impaction type forearm fracture affecting the radius, ulna or both at a single emergency clinic between June 2013 and August 2013. Patients aged between five and ten years were included. Each month (June, July, August) ten case and ten control patients were included in the study. Patients with a diagnosis of radius, ulna or

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both displaced forearm fractures, an underlying bone mineralisation disorder (including osteopenia, osteoporosis, osteogenesis imperfecta and osteopetrosis), current or previous steroid use and a chronic illness that may potentially be affecting bone density (including cancer, kidney or intestinal disorders, thyroid diseases and cerebral palsy) were excluded from the study.

Case study participants were recruited through the orthopaedic emergency clinic and control study participants were recruited through the paediatric outpatient unit. In the case group, the first ten forearm fractured patients of the month were included. Healthy control patients, who were admitted to the paediatric outpatient clinic and diagnosed with upper respiratory tract infection, otitis media, routine paediatric control, etc. were included and a random selection was done by a blinded physician. All participants and/or their families provided informed consent.

Chart review included demographic information, medical history, mechanism of injury (for case patients), physical activity levels, breast milk intake and vitamin D use as a newborn. Measurements included height and weight to determine BMI.

Anteroposterior (AP) and lateral (LAT) radiographs for both forearms were obtained in children with distal forearm pain and swelling after a traumatic event (shown in Fig. 1. Without a reduction manoeuvre, a short arm cast was applied to the case patients for two to three weeks. Peripheral venous blood samples were obtained and analysed for measurement of 25(OH) D, Ca, Mg, P, alkaline phosphatase (ALP) and parathyroid hormone (PTH). For bone age determination, left hand AP view was obtained in the control group.

Effect sizes were calculated based on the data after a pilot study. A minimum of 30 cases were considered to be sufficient for each group for the effect size to be 1.00 (for 25(OH) vitamin D), 80% power and 5% type 1 error.

Statistical analysis was carried out using Student's *t*-test for parametric data, the Mann-Whitney U (Wilcoxon rank test) test for non-parametric data and the chi-squared test for categorical data as appropriate (MedCalc B-8400, Ostend, Belgium; Microsoft Excel 2013, Redmond, WA, USA). A p value ≤ 0.05 was considered significant.

Results

The study sample included 30 case and 30 control patients. All fracture patterns were distal radius, ulna or both non-displaced impaction type fractures. Patient characteristics are summarised in Table 1. Patients' ages (8.2 *vs* 7.7, p = 0.46) and bone ages (7.7 *vs* 7.8, p = 0.83) were similar in both groups. The demographic characteristics of participants did not differ in terms of weekly physical activity levels and breast milk intake. History of vitamin D use in newborns tended to be lower in the case patients than in the controls, but there was no statistical difference determined (21 *vs* 24, p = 0.09). History of previous fracture was statistically high in the case group (6 *vs* 2, p = 0.03).

Mean whole body BMI was similar in both groups of patients (17.2 *vs* 16.7, p = 0.41). There were no obese patients (BMI > 30 or BMI percentile > 95%) in both group.

Blood counts are summarised in Table 2. Vitamin D levels (25(OH) D) are significantly lower in case patients (14.5 ng/mL *vs* 21.3 ng/mL, p = 0.002) (Fig. 2). Other blood parameters did not demonstrate significant differences between case and control patients.

Vitamin D replacement (200 IU/kg per day) was initiated for 14 patients in the case group and three patients in control group. Higher daily milk intake and higher sun exposure were advised to all case patients.

Discussion

Approximately half of all children will fracture a bone during childhood.[6,7] Forearm fractures are one of the most frequent injuries and may be considered to be an indicator of poor bone health; there is increasing evidence that such fractures may be related with future osteoporosis.[1,2] Recent studies suggested that poor nutrition, poor sunlight exposure, physical inactivity, pigmentation and genetics may be a function of lower bone mineral density.[8,9] Our purpose was to determine whether children with distal radius impaction fractures have increased prevalence of 25(OH) D levels compared with healthy peers and showed that deficiency may have

Table 1. Demographics and patient characteristics of the case and control groups

	Case group (n = 30)	Control group (n = 30)	p value
Age (yrs)	8.2 (2.6)	7.7 (2.1)	0.46
Bone age (yrs)	7.7 (2.3)	7.8 (2.5)	0.83
Gender (% male)	18/30 (59)	14/30 (46)	0.12
Height (cm (sd))	124 (7)	123 (6)	0.92
Weight (kg (sd))	28.1 (9.2)	27.2 (9.2)	0.70
BMI	17.2 (2.4)	16.7 (2.9)	0.41
Vitamin D before replacement	14 (46%)	3 (10%)	0.17

Table 2. Blood parameters of the case and control groups

	Case group (n = 30)	Control group (n = 30)	p value
Ca (mg/dL (sd))	9.9 (0.3)	9.7 (0.3)	0.10
Mg (mg/dL (sd))	2.0 (0.1)	2.0 (0.1)	0.83
P (mg/dL (sd))	4.9 (0.3)	4.7 (0.5)	0.12
ALP (IU/L (sd))	227 (36)	200 (76)	0.09
PTH (pg/mL (sd))	28.4 (15)	28.1 (14.7)	0.93
25(OH) D (ng/mL (sd))	14.5 (4.7)	21.3 (8.2)	0.0002*

*p is significant < 0.05

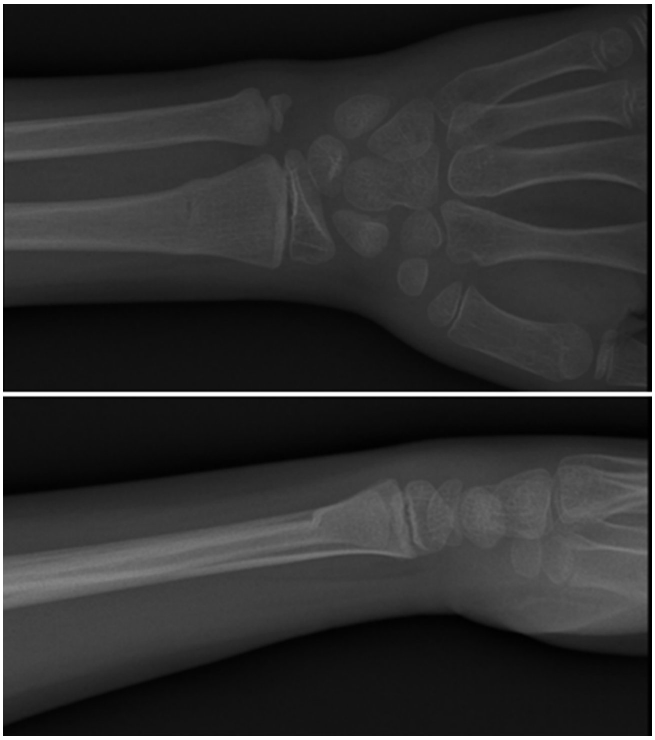

Fig. 1 Radiograph image of forearm fractures.

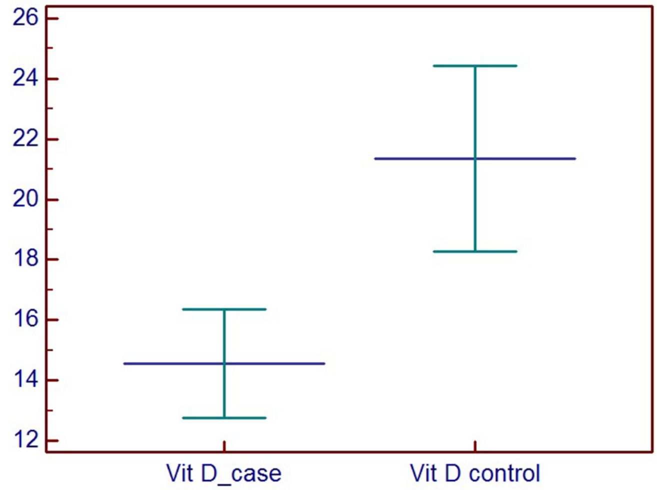

Fig. 2 25(OH) D level was significantly lower in case patients (14.5 *vs* 21.3, p = 0.002).

been associated with increased incidence of forearm fractures in children.

Vitamin D is essential for calcium haemostasis and bone remodelling.[10,12] Rickets in children has been recognised with poor bone quality and associated with increased risk of fracture.[10,13] An increased incidence of vitamin D deficiency and/or insufficiency was investigated in girls, obese children and children with darker skin pigmentation.[14-16] Adequate intake levels for vitamin D from food and/or milk are met by less than half of children in lower socioeconomic regions.[17,18] Also, infants born in such populations have low vitamin D stores and may receive little additional vitamin D if they are breastfed without supplements.[5] Lack of vitamin D supplementation in infancy leads to reduce bone mineralisation, slower growth and increased risk in fracture.[5,19]

In the last trimester of pregnancy and in newborns, vitamin D usage has been routinely advised to families as a supplement in the last few decades in Turkey. Although there was no statistical significance determined between case and control patients in our study, vitamin D usage tended to be lower in case patients (21 *vs* 24, p = 0.09). Also, a retrospective study by Zamora et al showed that 91 of 106 infants had received vitamin D supplements from birth to the age of six months.[20]

A recent study that assessed the association between serum 25(OH) D levels and fracture risk showed that 59% of African American children with fractures were vitamin D insufficient, and the authors noted that the prevalence was higher than their peers.[3] In another study, 189 children with fractures were analysed and 34% of them were vitamin D deficient.[21] In our study, the prevalence of vitamin D deficiency in case group was 26.4% and insufficiency was 52.8%. In the control patients, the prevalence of vitamin D deficiency was 6.6% and insufficiency was 16.5%. Ceroni et al demonstrated that there is no significant difference in serum 25(OH) D concentrations between healthy controls, children with lower limb fractures and those with upper limb fractures.[22] In that study, they also observed a high prevalence of vitamin D insufficiency among children in all groups.[22]

Several studies have examined the relationship between 25(OH) D levels and bone mineral density (BMD). Most of these studies showed significant association between 25(OH) D levels and BMD.[15,23,24] On the other hand, a number of alternative studies have failed to show significant correlation between vitamin D levels and BMD.[25,26] In the recent literature, data show an increased rate of vitamin D deficiency and decreased BMD in Egyptian children with forearm fractures, similar to our study.[27]

This study has some limitations. We did not include mean weekly milk intake, mean weekly sun exposure and BMD z scores. Some blood samples were collected at the beginning of the summer, when the children had not yet had enough sun exposure. The age range in our study was five to ten years. However, ages were not significantly different between the patients and the control group. Children aged six to 12 years were also analysed in the same group in a recent review.[26] Children aged three to ten years were involved in another study.[27]

In conclusion, the longer-term effects of vitamin D deficiency on bone growth and mass have been more difficult to determine.[5] We have demonstrated with the present study that the prevalence of vitamin D insufficiency or deficiency was higher in patients with forearm impaction type fracture than healthy controls and the baseline levels reported in the literature. In addition, there were no significant differences in serum Ca, Mg, P, ALP and PTH levels between healthy controls and case patients. Further studies are needed in order to determine the relationship between vitamin D levels and bone turnover.

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COMPLIANCE WITH ETHICAL STANDARDS

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ETHICAL STATEMENT

This is an Institutional Review Board-approved prospective review of children non-displaced impaction type forearm fracture affecting the radius, ulna or both at a single emergency clinic. This study was approved by the ethics committee of the Istanbul University Çapa Medical Faculty Hospital committee.

Informed consent: Informed consent was obtained from all parents of children included in the study.

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