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The correlation between Vitamin D deficiency and orthopaedic manifestations in children during the COVID-19 pandemic

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Abstract

Purpose: During the COVID-19 pandemic, vitamin D deficiency in children has been reported from many parts of the world, but no such study is available for Indian children. Vit-D deficiency leading to orthopaedic manifestations during the COVID-19 pandemic has not been reported till date. We studied the correlation between Vitamin D deficiency and orthopaedic manifestations during the COVID-19 pandemic in otherwise healthy children.

Methods: The study included children aged 5-18 years who had prolonged home confinement during the COVID-19 pandemic and exhibited signs of Vitamin D deficiency, such as proximal myopathy, deformity, and pathological fractures. This group was then compared to a similar group from the preceding two years.

Results: Total 36 children (9 preadolescent and 27 adolescents) were enrolled in the study group. Twenty-five children presented with genu varum/valgum, six had insufficiency fractures of femur neck, and five had proximal myopathy. After medical treatment, twenty-one children with deformities were either treated or advised growth modulation or osteotomy, and fractures were stabilized. All children with myopathy recovered with medical treatment, and all fractures united without complications.

Conclusion: There was sudden increase in children with Vitamin-D deficiency due to prolonged home confinement during the COVID-19 pandemic. We could not find any correlation between Vit-D levels, amount of delay, and the mode of presentation. Many presented late with orthopaedic problems requiring surgical interventions, which could have been prevented with timely diagnosis and Vit D supplementation.

Keywords: Vit-D deficiency, COVID-19 pandemic, Orthopaedic manifestation of Vit-D deficiency

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DOI- https://doi.org/10.13107/ijpo.2026.v12.i02.276
www.ijpoonline.com

Introduction

Vitamin D (Vit-D) is essential for the healthy development of the bones, and is vital for many other systems; it is now referred to as a hormone[1]. Sunlight exposure is necessary for the skin synthesis of Vit-D, and prolong indoor confinement can lead to reduced skin synthesis [2]. Osteomalacia occurs due to Vit-D deficiency leading to failure of mineralization of osteoid in children and adults. Rickets is a disease of growing bone caused by unmineralized matrix at the growth plate before fusion, due to Vit-D deficiency [2,3].

On 11th March, 2020 World Health Organization (WHO) declared COVID-19 a global pandemic. To restrict the spread of COVID-19, many countries implemented lockdowns; India declared a nationwide lockdown from 25th March to 31st May 2020 [5]. After the complete lockdown was called off, many apprehensive parents kept their children homebound, limiting their sun exposure. A few months after the lockdown ended, our institute had a sudden increase in the number of children presenting with lower limb deformity, walking difficulty, insufficiency fractures, and

Submitted: 19/01/2026; Reviewed: 14/02/2026; Accepted: 21/06/2026; Published: 10/08/2026

features consistent with proximal myopathy; all had either low Vit-D levels or frank rickets on x-ray.

Vit-D deficiency in children during the COVID-19 pandemic has been reported from various parts of the world [2, 6, 7, 8]. A population-based study of Vit-D levels in Indian children during the COVID-19 pandemic is not reported to date. There is no publication in world literature on orthopaedic manifestation of Vit-D deficiency in children during the COVID-19 pandemic. Hence, we decided to conduct a study of otherwise healthy children presenting with orthopaedic manifestations of Vit-D deficiency during the COVID-19 pandemic.

Figure 1: M/7 years (Patient no 27) with bilateral genu valgum and radiological signs of active rickets like cupping, fraying, and metaphyseal widening

Our study's objective was to assess the mode of presentation of children and adolescents with Vit-D deficiency, after prolonged home confinement during the COVID-19 pandemic. Additionally, we aimed to identify any correlations between Vit-D deficiency and orthopaedic manifestations.

Material and Methods

After approval from the Institutional Review Board, we conducted a retrospective study with prospective data collection of consecutive children presenting with musculoskeletal complaints due to Vit-D deficiency at a paediatric orthopaedic institute from September 2020 to August 2022. Informed consent of participation was taken from parents as the study involved children. Children fulfilling the following criteria were included in the study, 1) Age between 5-18 years at the time of presentation, 2) symptoms suggestive of Vit-D deficiency (genu valgum/varum, proximal myopathy, and pathological fracture), 3) history of prolonged home confinement after COVID-19 pandemic lockdown was called off, 4) onset of symptoms (before 31st December 2020). Patients with any other known medical condition interfering with Vit-D metabolism, past history of rickets, and trauma were excluded from the study.

All patients were asked for the onset and duration of the symptoms, duration of difficulty in walking, sitting cross-legged, and/or squatting, and history of injury. A specific inquiry was made to accompanying parents regarding activity reduction, sports aversion, early fatiguability, and the amount of outdoor time spent by children after the COVID-19 lockdown was lifted. All previous consultations and investigations were recorded. Patients were divided into three broad groups according to symptoms and examination: 1. Proximal myopathy, 2. Deformity (genu varum/valum), 3. Insufficiency fracture(s) of neck of femur (FNOF).

All walking patients were subjected to Gower's test, and a detailed neurological examination was done in patients with positive Gower's test. In patients with genu valgum or varum, severity was clinically measured by intermalleolar distance (IMD) or intercondylar distance (ICD), respectively [9, 10]. Patients with difficulty in walking and hip pain had a gentle, careful assessment of hip movements (active and passive).

The first investigation of choice in all three groups was an X-ray; children with proximal myopathy and suspected hip fractures had an X-ray of the pelvis with both hips, and children with deformity had a standing X-ray of both knees. In patients with suspicion of hip fracture, when the fracture line was not clearly visible on X-ray, an MRI of both hips was advised. A standing full-length scanogram was done in children with deformities if surgical correction was planned.

Patients with classical radiological signs of rickets (Fig. 1) were treated medically without haematological investigations.

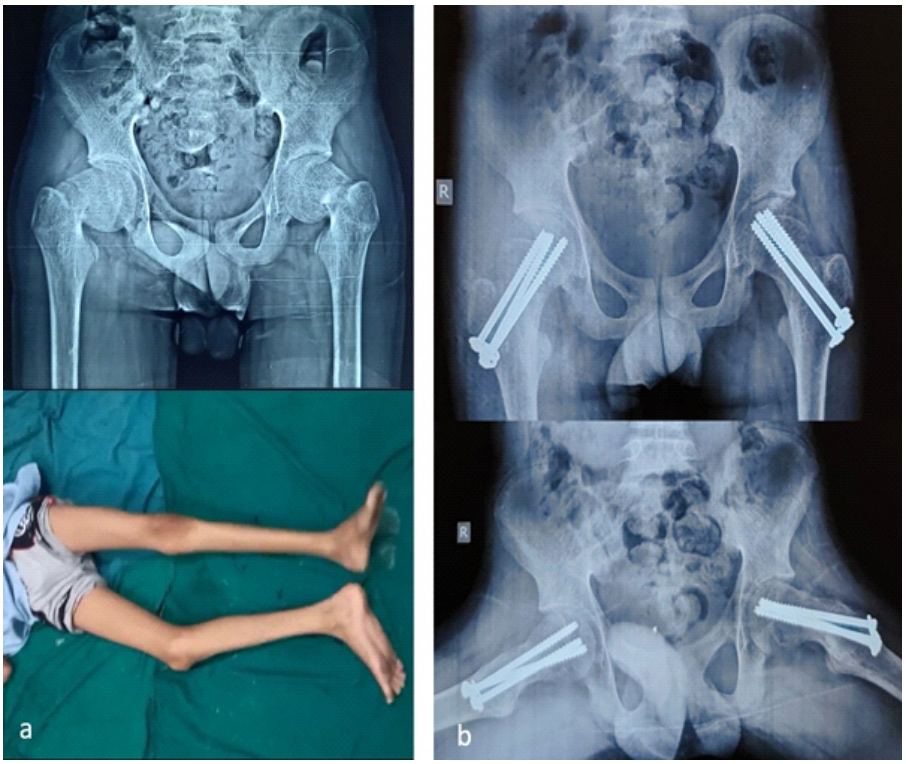

Figure 2: a. Bilateral displaced fracture neck femur in M/15 years (Patient no 33) brought on stretcher with bilaterally rotated limbs, b. X-rays after three months showed bilateral union without any complications

Patients without classical radiological signs of rickets were investigated for Vit-D and Alkaline phosphatase (ALP) levels. After confirming the diagnosis of Vit-D deficiency either by x-ray or haematological investigations, all the patients were treated with Stoss therapy i.e. high dose of oral Vit-D (6,00,000 IU), along with Calcium supplementation, sunlight exposure, and dietary guidance [3].

Children with proximal myopathy were treated with medical treatment only. Children with insufficiency fractures were stabilized with screws as soon as possible, along with medical treatment. Younger children with mild genu valgum/varum were observed for spontaneous correction of deformity with medical treatment. After a minimum of four weeks of Vit-D, and calcium supplementation, children with open physis were offered growth modulation, and skeletally mature adolescents were offered osteotomy.

Patients with proximal myopathy on medical treatment were assessed for symptomatic improvement, and subjected to Gower's test after four weeks of medical treatment. Patients with milder deformities were treated with only medical treatment and were followed up monthly for the first two months, and then every three months till deformity correction. Children with severe deformities were treated by growth modulation with 8 plates or percutaneous epiphysiodesis with transphyseal screws (PETS) and were assessed monthly for the first three months, and every three months thereafter. They were assessed for recovery of knee movements, implant-related problems, and the amount of deformity correction by serial measurements of IMD/ICD. Skeletally mature adolescents treated with osteotomy were assessed monthly till osteotomy union and every three months thereafter; they were assessed for knee movements, implant-related problems, and union status. Patients with fractures were seen initially every month till fracture union, and then every three months for hip movements, and for complications related to FNOF.

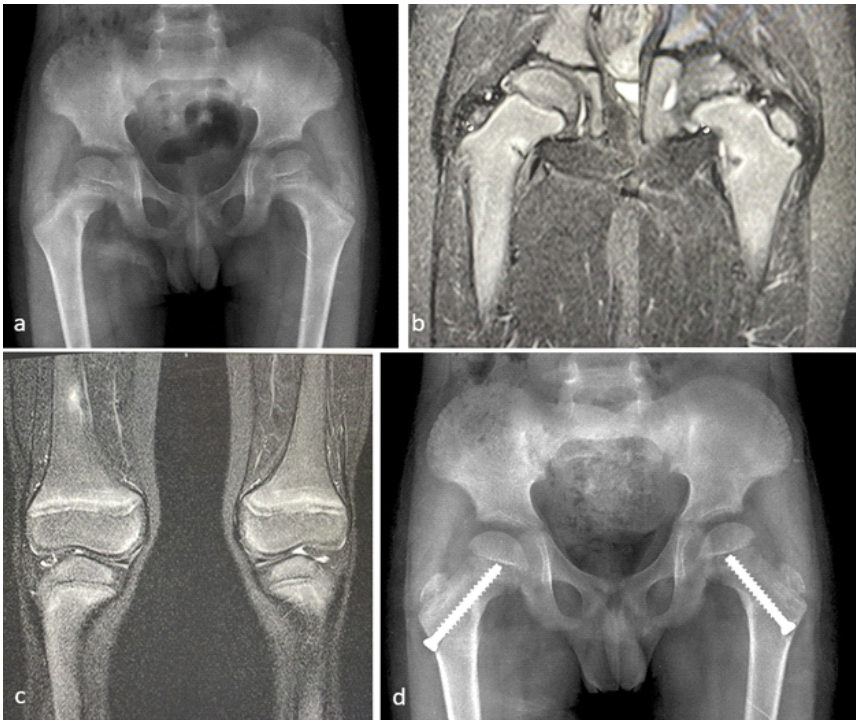

Figure 3: a. M/8 years (Patient no 13) with bilateral insufficiency fracture neck femur with signs of active rickets, b. MRI showing bilateral insufficiency fractures in inferior neck, c. Right distal femoral shaft showing signal changes suggestive of Looser's zone, d. X-ray one month after percutaneous single screw stabilization

Statistical analysis was done using SPSS (version 20). Data was not normally distributed (Shapiro-Wilk, $p<0.05$), therefore Mann-Whitney U test was used as a test of significance. Significance level was set at <0.05.

Results

From September 2020 to August 2022 a total of 36 children presented to our institute with complaints related to proximal myopathy, genu valgum/varum, or gait abnormalities with hip pain. There were 27 female and 9 male patients with an average age at presentation of 11.9 years (6-17 years). As per WHO definition [11], patients were divided into two groups: the preadolescent group (<10 years) had 9 children (25%) and the adolescent group (≥10 years) had 27 children (75%). As per the division of patients into three clinical groups, four patients had proximal myopathy, 26 had deformities, and six had insufficiency FNOF. (Table 1).

Of the total 36 patients, 16 children had walking difficulty as the chief complaint (12 adolescents) ;14 of them had an abnormal gait, while 2 with displaced FNOF were unable to walk and were brought on a stretcher; both of them had prolonged limping before they stopped walking. The cause of walking difficulty in six children was deformity, four had proximal myopathy, and six had insufficiency fractures.

Of 12 adolescents with walking difficulty, nine complained of difficulty with stairs; they found coming down the stairs more difficult than going up. One girl had a unique complaint of inability to jump. Gower's test was positive in seven adolescents (four proximal myopathy, three genu valgum), none in the preadolescent group had a positive Gower test. Of 26 children with knee deformity, 25 had genu valgum, and only one had genu varum. At the time of presentation, genu valgum patients had an average IMD of 14.47 (8-22.5) cm, and the child with genu varum had ICD of 11.5 cm (Table 1).

Diagnosis of Vit-D deficiency was done by measuring Vit-D levels in 28 patients (23 adolescent and 5 preadolescent); in the remaining eight patients, active rachitic changes on X-ray confirmed diagnosis in four children (Fig. 1), while four patients were diagnosed and treated elsewhere.

According to WHO criteria the children with Vit- D deficiency were classified into three categories: 1) deficiency - 25-D levels < 20ng/mL, 2) insufficiency - 25-D levels between 20-29 ng/mL, and 3) sufficiency - 25-D levels >30 ng/mL(15). In our cohort, seven had Vit-D levels below 5 ng/mL, twelve had levels between 5-10 ng/mL, eight had levels between 10-20 ng/mL, and one had levels between 20-30 ng/mL. The Vit-D level that was discovered to be the lowest was <3 ng/mL.

Alkaline phosphatase levels were found in the range of 295-1884 (Table 1). Surprisingly, three adolescents with low Vit-D levels were found to have ALP < 300. Additional blood investigations like serum calcium, phosphorus, creatinine kinase, serum uric acid, SGPT, SGOT, thyroid function tests were also done in a few patients before presenting to us. One adolescent girl (no. 10) with Down's syndrome presented with difficulty in walking for the past six months; she had Vit-D levels of 19.44 ng/mL with signs of active rickets on x-ray. She was found to have associated hypothyroidism and was managed by paediatric endocrinologist. She had gait improvement and radiological healing of rickets at two months.

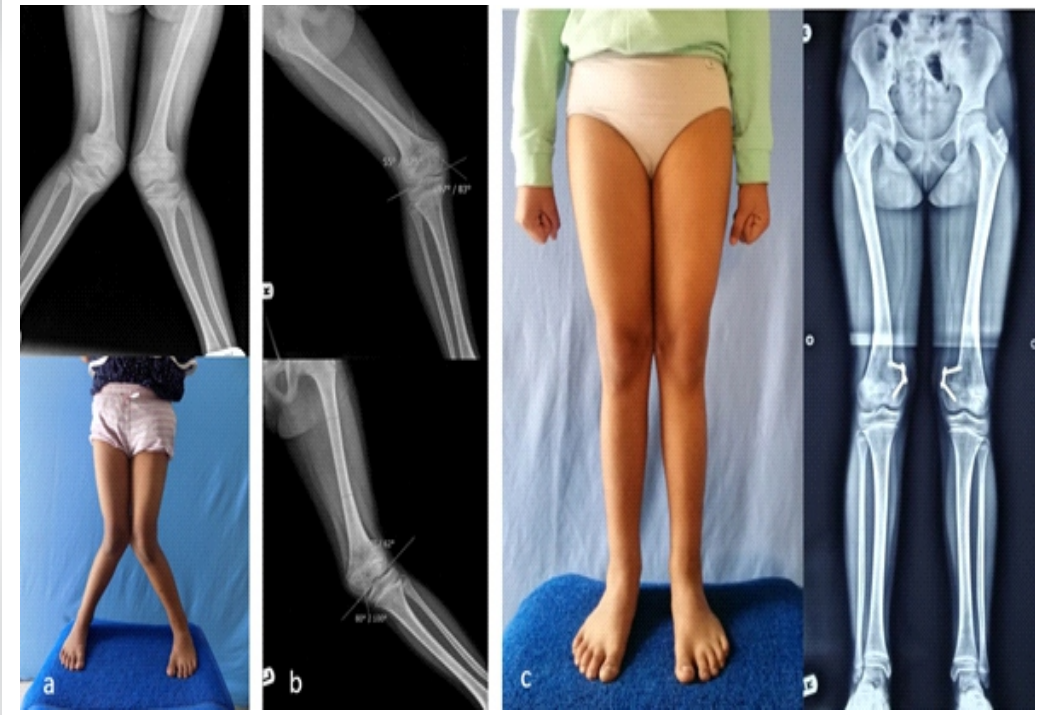

Figure 4: a. F/9 years (Patient no 12) with bilateral genu valgum with signs of active rickets, b. X-ray before surgery after six weeks of medical treatment showing healed rickets and distal femoral valgus, c. Excellent deformity correction 18 months after bilateral distal femoral 8 plate application

Of six children with FNOF, two patients with the inability to walk had bilateral FNOF; one patient (no. 32) had one side undisplaced, and another side displaced fracture, while another patient (no. 36) had bilateral displaced fractures(Fig . 2). The remaining four patients had difficulty walking along with hip pain; on clinical examination, they had

restricted and painful hip internal rotation. Three of them had bilateral, and one had unilateral insufficiency FNOF. Of four patients with insufficiency fractures, three underwent MRI, and one had a CT scan for the confirmation of diagnosis. One patient (no. 35) with a unilateral fracture on x-ray was found to have bilateral insufficiency fractures on MRI.

Two patients on MRI had findings suggestive of Looser's zone; one in the distal femur shaft (no. 9) (Fig. 3) and one in the proximal femoral shaft (no.36). Looser's zone on x-ray was visible in one adolescent girl (no. 29) who presented to us with proximal myopathy and had positive Gower's sign.

Four patients with radiologically active rickets were treated medically without any haematological investigations (Fig. 1); all of them showed complete radiological healing at two-month follow-up. Patients with proximal myopathy showed significant gait improvement after four weeks of medical treatment, and their Gower's test became negative; their parents observed improvement in activity levels and sports participation. Complete normalization of gait was achieved by 12 to 16 weeks.

Of the nine preadolescents, eight presented with deformity, and one had bilateral insufficiency FNOF. Five preadolescents with milder deformity (average IMD 12cm) improved with only medical treatment, while three preadolescents with severe deformity (average IMD 18.8cm) needed growth modulation for genu valgum (one 8-plate, 2 PETS) (Fig. 4). Preadolescent (no. 9) with bilateral insufficiency FNOF was treated with in-situ fixation.

Of the total 27 adolescents, 18 presented with deformities; five of them had growth modulation (genu valgum-4, genu varum-1); four had PETS, and one had 8 plates (Table 1). Four patients were advised growth modulation, but their parents refused. Three patients with skeletal maturity underwent osteotomy for genu valgum; two (no. 22, 26) had unilateral osteotomy (one distal femoral and one proximal tibial), and one had (no. 35) bilateral proximal tibial osteotomy. Six patients were recommended osteotomy, but have not undergone the corrective procedure yet. Among these, two patients were initially advised growth modulation elsewhere; after bone-age estimation at our centre, they were found to have an advanced skeletal age, and were advised osteotomy instead of growth modulation.

Of five adolescents with FNOF, two displaced FNOF underwent bilateral single-stage stabilization; Pt 11 had right side in-situ screw fixation, and had ORIF with paediatric DHS and one cc screw fixation on the left, and Pt 33 had bilateral closed reduction and screw fixation(Fig. 2). Of the remaining three patients with insufficiency fractures, two underwent bilateral percutaneous in-situ screw fixation; one patient (no.14) refused surgery; she developed coxa vara bilaterally on follow-up. All patients with FNOF united without complications and have a normal gait.

Our cohort had higher adolescents compared to preadolescents. The mean age of presentation in the deformity group was 12.7 years, in myopathy group 12.75 years, and in the fracture group 15.4 years; the difference was statistically significant (P value <0.05).

We reviewed records at our institute for the age group of 5-18 years presenting with Vitamin D deficiency; we could identify only three patients. Among these, one patient was from the preadolescent group, while the remaining two were from the adolescent group; two cases had genu valgum, and one case had a tibial stress fracture. The preadolescent of this group with genu valgum was managed medically and the adolescent girl with genu valgum had unilateral distal femoral osteotomy and is awaiting correction on the opposite side. The adolescent with a tibial stress fracture was investigated with MRI and managed with a plaster cast alongwith medical treatment. (Table 1)

Statistical analysis did not find any association between mode of presentation and Vit-D levels in both preadolescent (p value < 0.4) and adolescent groups (p value < 0.7). In the adolescent group, the mean Vit-D levels in the non-deformity group (proximal myopathy and fracture cases) were 8.89, while in the deformity group mean Vit-D levels were 14.46. The difference was statistically significant. (p value < 0.05). The level of Vit-D and severity of the deformity (measured by IMD, ICD) in the adolescent group had a weak negative correlation; however, it was not statistically significant (p value 0.63). The difference between Vit-D and Ca levels in boys and girls was not statistically significant. Serum ALP levels were significantly lower in boys compared to girls (P value .02).

Discussion

The current views suggest that Vit D is more of a multifunctional hormone or prohormone, as it contributes to many processes [1]. Cholecalciferol is synthesized in the skin from 7-dehydrocholesterol with the help of UV-B (290-315 nm) radiations of sun rays. In the liver, it is converted by 25-hydroxylase to 25-hydroxy Vit-D (25-OH-D) and finally, in the kidney, it is converted to active form 1-25 dihydroxy Vit-D (1,25-OH2-D) [12]. As the skin synthesis of Vit D depends on sun exposure, air pollution, indoor living and the use of sunscreen affect Vit-D synthesis [2]. It is well-known fact that Vit-D deficiency is a serious health problem affecting not only the musculoskeletal system but leads to other diseases like diabetes, cardiovascular disease, cancers, depression, and many more [13]. American academy of paediatrics has revised the minimal daily requirement of Vit-D from 200 IU to 400 IU for children and adolescents [12]. Vit-D deficiency is known to cause deformities around the knee region, pathological fractures, and proximal myopathy [3, 4].

On 25th March 2020, the Government of India declared a nationwide lockdown due to the COVID-19 pandemic [5].

Social distancing measures included school and college closure. After the lockdown was lifted, many parents were scared to send their children outdoors due to fear of catching COVID-19 infection; this decreased the sun-light exposure in children leading to Vit-D deficiency. Multiple authors from China, Poland, Malaysia, and Turkey have reported Vit-D deficiency in paediatric population during the COVID-19 pandemic due to prolong home confinement [2, 6, 7]. As of now, there are no studies available on the estimation of Vit-D levels during the COVID-19 pandemic in Indian children. To the best of our knowledge, no author worldwide has reported on the orthopaedic manifestations of Vit-D deficiency in children and adolescents during the COVID-19 pandemic.

Although India is a sunny country, many researchers from different parts of India have reported a 3.3-27% incidence of rickets in children [14]. According to WHO, 25-D levels < 20 ng/mL are considered as a deficiency, 20-29 ng/mL is insufficiency, and >30 ng/mL is considered sufficiency [15]. In our study, we found that 27 out of 28 tested patients had Vit-D levels below 20 ng/mL; 12 of them had had vit-D levels below 10 ng/mL, and seven had extremely low vit- D levels (below 5 ng/mL); the lowest level was <3.5 ng/mL. In patients with rachitic changes on X-ray, Vit-D estimation was not done, as it is an expensive investigation. Instead, we started them directly on Stoss therapy [3]. Along with Vit-D, Ca Carbonate supplementation was given containing the highest elemental Calcium(13%).

Of 36 total patients, 75% (27 children) belonged to adolescent group. In a review article, Cashman reported a high prevalence of low Vit-D levels in adolescents from the USA, Europe, New Zealand, and Lebanon and attributed them to low sun exposure and low Vit-D intake [4]. Soliman noted that compared to children, adolescents with Vit D deficiency have relatively higher serum Ca, PO4, and lower PTH and ALP levels [16]. We found ALP elevated in 18 adolescents. During our study, we chose not to conduct Ca, Po4, and PTH level tests because we believed that adding more investigations for this group of otherwise healthy children with classical history and symptoms would impose an unnecessary financial burden on parents. Furthermore, we felt that these additional tests would not provide any significant additional information regarding the diagnosis or monitoring of the condition.

The first patient with difficulty in walking and climbing stairs was a 15-year-old girl; she had multiple previous consultations before presenting to us. On examination, she had a positive Gower's test and could not climb stairs without support; her pelvic x-ray was normal, but her Vit-D levels were < 4 ng/mL. She was diagnosed with osteomalacic myopathy. After four weeks of treatment, her difficulty in climbing stairs improved and her Gower's test became negative but normalization of gait took 16 weeks. Holicks from the Mayo Clinic has noted that proximal myopathy is an important feature of Vit-D deficiency and noted that symptoms of rickets such as widening of metaphysis and deformity, manifest after 6-18 months [13].

Soliman et al noted that in adolescents, Vit-D deficiency may be asymptomatic and go undetected; they present with vague symptoms like pain in thighs and/or calves, difficulty in walking and/or climbing stairs, and getting up from a squatting position. These vague symptoms are misdiagnosed as fibromyalgia, chronic fatigue syndrome, or simply depression. They noted that a diagnosis can be made based on the classic clinical profile of bone pain, fractures, and proximal myopathy with low Vit-D levels on estimation [16]. Goraya et al from India reported 26 children with progressive walking difficulty due to osteomalacic myopathy, of which 58% were adolescents; six children eventually lost ambulation. They noted that there is nothing specific in osteomalacic myopathy, and found it commonly misdiagnosed as an inherited disease, an inflammatory disease, or a psychiatric disorder. They concluded that a diagnosis can be made by appropriate laboratory and radiographic investigations, but the final confirmation is made when Vit-D supplementation leads to the resolution of symptoms [17]. Hazzazi from Riyadh reported 135 adolescents with osteomalacia, of which 57 patients (32 girls) had nutritional osteomalacia; 17.5% had bony deformities, and 14% had fractures [18].

Most of our patients sought the first medical care from family physicians, pediatricians, or orthopedic surgeons before presenting to us. Surprisingly, none of these initial healthcare providers considered Vit-D deficiency as a potential cause of their patients' symptoms and few patients were referred to rheumatologists and neurologists. Many patients had undergone a plethora of investigations, such as RA factor, anti-CCP, and ANA to rule out inflammatory arthritis, CPK levels to rule out myopathy, and nerve conduction testing to rule out neuropathy. Additionally, MRI scans of the spine and brain were performed. However, despite these efforts, a definitive diagnosis remained elusive. In one patient (no.33), an MRI of the lumbar spine was advised, and a radiologist reported an insufficiency fracture of the femoral neck; somehow, attention was not paid to the report. He continued walking with difficulty, and unfortunately, he presented to us on a stretcher with bilateral displaced FNOF.

Nikolaos et al., over 25 years, reported 37 cases of stress fractures in children and found only two cases of stress fractures in the femoral neck. The most commonly involved regions were the tibia and fibula, with two cases involving the distal femur. Contrarily, we had six cases of femoral neck insufficiency fractures in a very short span of 23 months (September '20 to August '22); significantly higher than reported in the literature to date. In both cases of femur neck stress fractures reported by Nikolas, the diagnosis was missed initially; one patient with hip

Table 1 – Master chart

Sr. No.	Patient information	Chief complaints	IMD/ICD (cm)	Management	Vit D (ng/dl)	Serum ALP levels
1	F/9	DW, PM	-	Medical	12.39	NA
2	F/9	DW, B/L GV	9	Medical	6.6	1522
3	F/12	DW, B/L GV	15	Medical	19.44	1884.37
4	M/12	DW, PM	-	Medical	6.04	NA
5	F/15	DW, PM	-	Medical	70.58	NA
6	F/13	DW, B/L GV	14.5	Medical	3.9	652.3
7	M/11	DW, PM	-	Medical	7.59	462.89
8	F/12	B/L GV	11	Medical	<3.5	522
9	F/11	B/L GV	12.5	Medical B/L DF-PETS	NA	NA
10	M/15	B/L GV	15	B/L DF-PETS	NA	791
11	F/14	DW, B/L IF	-	Rt. CRIF, Lt. ORIF	12.35	308.48
12	F/9	B/L GV	25	B/L DF 8 plate	NA	NA
13	M/8	DW, B/L IF	-	B/L in situ CC screw	6.1	785.88
14	F/16	DW, B/L IF	-	Medical, refused surgery	5.44	769.2
15	F/13	B/L GV	13.5	Medical and B/L DF 8 plate	20.04	577.38
16	F/17	DW, B/L IF	-	B/L in situ CC screw	8.4	1553.8
17	M/9	DW, B/L GV	16	B/L DF-PETS	NA	NA
18	F/12	B/L GV	8	GM offered	NA	NA
19	F/6	B/L GV	13.5	Medical	NA	NA
20	F/7	B/L GV	-	Medical	4.45	1188.7
21	F/8	B/L GV	15.5	B/L DF & PT PETS	11.91	NA
22	F/15	B/L GV, DW	16	Left PT osteotomy	NA	NA
23	F/11	B/L GV	17	Osteotomy offered	NA	NA
24	F/12	B/L GV	15	Osteotomy offered	NA	NA
25	F/12	B/L GV	16	Osteotomy offered	4.7	797
26	F/14	Right GV	11	DFO	NA	NA
27	F/7	Left GV	13.5	Medical	NA	NA
28	M/13	DW, PM	-	Medical	8.5	274
29	F/15	DW, B/L IF	-	B/L in situ CC screw	7.1	824
30	F/15	B/L GV	16	Osteotomy offered	4.8	833
31	F/14	B/L GV	15.5	Osteotomy offered	<3.5	553.9
32	F/11	B/L GV	14.5	Osteotomy offered	<3	754
33	M/15	B/L IF (displaced)	-	B/L CRIF	109	742
34	M/12	B/L GV	11.5	B/L PT PETS	15.9	149.1
35	M/13	B/L GR	ICD 11.5	Medical and GM advised	7	248
36	M/13	B/L GV	22.5	Medical & B/L PETS DF+PT	7.7	517

DW – Difficulty in walking, PM- proximal myopathy, GV- Genu valgum, GR- Genu varum, IF- insufficiency fracture, IMD- Intermalleolar distance, ICD - Intercondylar distance, GM = Growth modulation, PETS - Percutaneous Epiphysiodesis using Transphyseal Screw, CRIF - Close Reduction and Internal Fixation, ORIF- Open Reduction and Internal Fixation, DF-Distal femoral, PT-proximal tibial, DFO- Distal Femoral Osteotomy

pain and an inconclusive pelvic x-ray presented with a displaced FNOF after a trivial fall. The same happened with one of our patients (no. 33).

Two of our patients with hip pain and difficulty in walking, the fracture line was not clearly visible on the X-ray; we resorted to MRI for confirmation of the diagnosis. On MRI, one patient with a unilateral fracture on X-ray was found to have bilateral femur neck fractures(no.29), and two patients (no.13, 33) were found to have additional distal femoral Looser's zones (Fig. 3). Due to the nonavailability of an MRI centre in the vicinity, patient no.14 got a CT scan for the confirmation of an insufficiency femur neck fracture. Cabarrus noted MRI to be superior to CT in the diagnosis of insufficiency fractures, especially for the femoral head and acetabulum [19]. We agree with their findings and believe that children who show strong clinical suspicion of an insufficiency FNOF with an uncertain radiological picture should undergo an MRI. Missing the diagnosis at this point could lead to the patient missing the chance for a straightforward single screw stabilization procedure. Instead, they may continue to walk and eventually present with a displaced FNOF, requiring a more complex surgery with higher rates of complication.

In rickets, generalized softening of the bones occurs, leading to the bending of weight-bearing bones, causing genu valgum or varum [3]. In our study, the most common presentation (25 out of 36) was knee deformity. To measure the amount of correction on follow-up serial measurements of IMD and ICD were done to avoid frequent X-rays [9, 10]. Chabra et al studied 16274 children aged 1 to 18 years in Assam, India, and found 2.7/1000 children with skeletal deformity secondary to nutritional rickets [14]. In their series, genu valgum(54.54%) was more common than genu varum(25.92%), which is similar to our study; 24 of our children had genu valgum, and only one had genu varum.

Peter Stevens (2007) reported successful correction of post-rachitic deformity in a 9-year-old child with 8 plates that he invented [20]. We have successfully used guided growth in eight patients; 8 plates were used in two (Fig. 4), and PETS in six. All patients had successful deformity correction with growth modulation, and seven of them have undergone implant removal; one of them has reached skeletal maturity (patient no. 10), hence his screws were not removed. One child (no 36) had partial correction of IMD after PETS due to fusion epiphysis around the knee; he will require osteotomy on both sides. Three of our patients (no. 22, 26, 35) with genu valgum had reached skeletal maturity and were managed with osteotomy. All three of them had symptoms of Vit-D deficiency for more than 18 months and were seen by primary care physicians. If a timely diagnosis of Vit-D deficiency had been made in them, they could have benefitted with growth modulation. Two patients were advised to undergo growth modulation elsewhere without assessing their bone age. At our centre, on bone age assessement was done with the Souvegrain method which has been validated for Indian children [21]; they were found to have advanced bone age and were advised osteotomy instead of growth modulation.

During our investigation, we were astonished to discover that over the two years preceding the COVID-19 pandemic, only three patients over 5 years of age (one preadolescent and two adolescents) with Vit-D deficiency were recorded at our institute. However, during the 23 months of our study period, the number significantly increased to 36 patients. Despite the substantial difference in sample sizes between the two periods, when we applied Chi-square with Yates correction for statistical analysis, the results revealed that the difference was not statistically significant ($p = 0.75$).

This study has certain limitations that should be acknowledged. Firstly, the cohort was obtained within a specific time frame during the COVID-19 pandemic, and the majority of the children presented to us late with significant deformities and fractures. Therefore, relying solely on medical treatment was not justifiable, which led to the absence of a comparable control group treated exclusively with medical interventions.

Based on our statistical analysis, we did not find any significant correlation between Vit-D levels and the mode of presentation (myopathy, deformity, or fracture). It appears that children with Vit-D deficiency could present with myopathy, deformities, or fractures irrespective of their Vit-D levels and the duration of their symptoms.

Based on our observations, we came to realize that similar to reports from various countries worldwide, Indian children also developed Vit-D deficiency during the COVID-19 pandemic due to prolong home confinement [2, 6, 7, 8]. Unfortunately, in numerous cases, primary care physicians failed to recognize the early symptoms of Vit-D deficiency in children and adolescents, leading to numerous unnecessary investigations, and referrals, resulting in additional costs and delay. Consequently, many children presented late with significant deformities and insufficiency fractures, necessitating surgical intervention. All of these could have been prevented if timely Vitamin D supplementation had been initiated.

With the few COVID waves in many parts of the world, the fight against COVID-19 seems far from over [22]. We feel sensitizing primary care physicians to check Vit-D deficiency in children after prolonged home confinement is very important. An aware primary care physician can save many unnecessary investigations and surgical interventions by a timely diagnosis of Vit-D deficiency. In developing countries like India, due to the scarcity of doctors in the hinterland, parents also should be encouraged to give Vit-D supplementations regularly and should be educated about the signs and symptoms of Vit-D deficiency via media advertising and social media.

Implementing community screening measures for detecting Vit-D deficiency in children and providing early Vit-D supplementation would prove immensely valuable in preventing avoidable surgical interventions.

Conclusion

During the COVID-19 pandemic, in a short span of 23 months, we received 36 patients with orthopaedic manifestations of Vit-D deficiency, like proximal myopathy [4], deformities [26], and fractures [6]. Of 28 tested patients, Vit-D levels were found to be low in 27, while others exhibited radiologically active rickets. Unfortunately, the lack of awareness among primary care physicians regarding the high prevalence of Vit-D deficiency in children during the COVID-19 pandemic led to delayed presentations. No correlation was found between Vit-D levels, the extent of delay, and the mode of presentation. Deformity improved with medical treatment in only five young children; eleven patients have undergone surgical corrections, and ten are awaiting. All five patients with fractures needed fixation. These surgical interventions could have been prevented with timely diagnosis and treatment of Vit-D deficiency. We strongly feel the need of sensitizing primary care physicians and parents towards the high prevalence of Vit-D deficiency in children following prolonged home confinement such as during the COVID-19 pandemic is invaluable, as the crisis like the COVID-19 pandemic is far from over.

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Declaration of patient consent : The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given the consent for his/ her images and other clinical information to be reported in the journal. The patient understands that his/ her names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Conflict of interest: Nil **Source of support:** None

How to Cite this Article

Naik P, Mehta MM | The correlation between Vitamin D deficiency and orthopaedic manifestations in children during the COVID-19 pandemic | International Journal of Paediatric Orthopaedics | May-August 2026; 12(2): 26-35.