RESEARCH PAPER

Bone Mineral Density Changes in Children with Celiac Disease

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ABSTRACT

Background: Celiac disease is a chronic immune-mediated disorder associated with intestinal malabsorption and multiple extraintestinal complications, including impaired bone health. Children with celiac disease are at increased risk of reduced bone mineral density due to nutritional deficiencies and chronic inflammation. **Objective:** To evaluate bone mineral density changes in children with celiac disease and identify factors associated with reduced bone health. **Methods:** This cross-sectional analytical study was conducted at Farooq Hospital Lahore from January 2025 to January 2026 including 140 children diagnosed with celiac disease. **Results:** The mean age of participants was 9.8 ± 3.7 years, with females comprising 55.7% of cases. Mean DEXA Z-score was -1.9 ± 0.9. Osteopenia and osteoporosis were identified in 61 (43.6%) and 27 (19.3%) children, respectively. Children with reduced bone mineral density had significantly lower BMI (15.6 ± 2.3 vs. 17.5 ± 2.1 kg/m²; $p<0.001$) and lower vitamin D levels (16.9 ± 6.8 vs. 24.1 ± 6.2 ng/mL; $p<0.001$). Poor dietary compliance and growth retardation were significantly associated with reduced bone mineral density. Logistic regression analysis identified vitamin D deficiency (aOR 3.42; $p=0.001$), growth retardation (aOR 3.11; $p=0.004$), and poor dietary compliance (aOR 2.89; $p=0.009$) as significant predictors of reduced bone mineral density. **Conclusion:** Reduced bone mineral density is highly prevalent among children with celiac disease and is strongly associated with nutritional deficiencies and poor dietary adherence. Early diagnosis and effective nutritional management are essential to improve skeletal health outcomes.

Keywords: Celiac disease; Bone mineral density; Osteopenia; Osteoporosis; Children; Vitamin D deficiency.
How to cite this article: Iqbal MS, Langah A, Muhammad T, Nazir M, Khan SI, Tolibovna ZV. Bone Mineral Density Changes in Children with Celiac Disease. Int J Drug Deliv Technol. 2026;16(54s): 734-738. DOI: 10.25258/ijddt.16.54s.66

INTRODUCTION

Celiac disease is a chronic immune-mediated enteropathy following ingestion of gluten in genetically predisposed individuals, characterized by villous atrophy and malabsorption, mainly in the small intestine [1]. It is one of the most frequent chronic gastrointestinal diseases in children and there are many gastrointestinal and extraintestinal features [2]. While classically the clinical picture is one of chronic diarrhea, abdominal distention, and loss of weight, many children have either atypical or silent disease [3]. Impaired bone health is among the important extraintestinal manifestations of celiac disease, and has become a growing clinical interest [4]. Due to chronic nutrient malabsorption and systemic inflammation, children with celiac disease are at greater risk for reduced bone mineral density (BMD), for osteopenia and osteoporosis [5]. Because childhood and adolescence are times of rapid skeletal growth and development and of peak bone mass acquisition, untreated celiac disease could have a negative long-term impact on bone health and fracture risk [6]. There are several factors involved in low bone mineral density in those with celiac disease. The villous atrophy reduces the absorption of calcium, vitamin D, magnesium and phosphate, which causes secondary hyperparathyroidism and increases the bone resorption [7]. Chronic inflammation and higher levels of inflammatory cytokines (like tumor necrosis factor-alpha and interleukins) may be additional factors in the developmental changes in bone, including reduced bone formation [8]. Other factors which contribute to this are malnutrition, delayed growth, and low BMI [9].

The BMD values have been found to be significantly decreased in the children with untreated celiac disease

in several studies, as compared with healthy children of similar age [10]. Low bone density can also be observed in patients without any gastrointestinal symptoms or in those who do have symptoms but do not present with any complications to the bone, therefore screening for bone complications should be performed regularly [11]. In children, DEXA is regarded as the most accurate method for measuring bone mineral density, and is useful in detecting early osteopenia or osteoporosis [12]. The central tenet of treatment of celiac disease is the strict gluten-free diet, which has been shown to cause improvement in intestinal mucosal healing and nutrient absorption [13]. In the past, it has been demonstrated that in many children, the gradual recovery of bone mineral density can be achieved with early diagnosis and compliance with diet [14]. The degree of recovery, however, is different for each patient, depending on the age of diagnosis, severity of the disease, nutritional deficiencies and compliance with treatment [15]. In some children, low bone mineral density has been observed despite therapy and further long-term monitoring together with nutritional support are recommended [16]. Therefore, the early diagnosis of skeletal involvement is crucial in order to avoid fractures, optimize growth and quality of life in children with celiac disease [17].

Objective

To evaluate bone mineral density changes in children with celiac disease and identify factors associated with reduced bone health.

METHODOLOGY

This was a cross-sectional analytical study conducted at Farooq Hospital Lahore from January 2025 to January 2026 including 140 children diagnosed with celiac disease to evaluate changes in bone mineral density and associated clinical factors.

Inclusion Criteria

- Children aged 2–18 years diagnosed with celiac disease based on serological and/or biopsy findings
- Patients on regular follow-up for celiac disease management
- Patients who underwent bone mineral density assessment using DEXA scan
- Parents or guardians willing to provide informed consent

Exclusion Criteria

- Children with chronic diseases affecting bone metabolism such as chronic kidney disease, endocrine disorders, or malignancy
- Patients receiving corticosteroids or medications affecting bone density
- Children with congenital bone disorders
- Patients with incomplete medical records or missing DEXA scan data
- Patients with poor compliance to follow-up evaluations

Data Collection

After obtaining ethical approval, data were collected using a structured proforma. Baseline demographic and clinical variables included age, gender, duration of symptoms, age at diagnosis, body mass index (BMI), dietary compliance, and presenting symptoms. Laboratory investigations including hemoglobin, serum calcium, phosphate, vitamin D levels, and tissue transglutaminase antibody levels were recorded. Bone mineral density was assessed using dual-energy X-ray absorptiometry (DEXA) scan, and Z-scores were documented. Osteopenia and osteoporosis were classified according to age-adjusted pediatric reference values. Associations between bone mineral density changes and clinical or biochemical parameters were also evaluated.

Statistical Analysis

Data were analyzed using SPSS version 26.0. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequency and percentage. Independent t-tests and chi-square tests were used to compare variables among patients with normal and reduced bone mineral density. Logistic regression analysis was performed to identify predictors of low bone mineral density. A p-value ≤ 0.05 was considered statistically significant.

RESULTS

The study included 140 children with celiac disease, with a mean age of 9.8 ± 3.7 years. Females were slightly more common, accounting for 78 (55.7%) cases. The mean duration of symptoms was 14.6 ± 6.9 months, while the mean age at diagnosis was 7.9 ± 3.2 years. Mean BMI was relatively low at 16.3 ± 2.4 kg/m², reflecting nutritional compromise. Poor dietary compliance was observed in 46 (32.9%) children. Common presenting symptoms included abdominal pain in 88 (62.9%), chronic diarrhea in 79 (56.4%), and growth retardation in 58 (41.4%) patients.

Table 1: Baseline Demographic and Clinical Characteristics of Children with Celiac Disease (n = 140)

Variable	Value
Age (years), mean ± SD	9.8 ± 3.7
Male Gender, n (%)	62 (44.3%)
Female Gender, n (%)	78 (55.7%)
Duration of Symptoms (months), mean ± SD	14.6 ± 6.9
Age at Diagnosis (years), mean ± SD	7.9 ± 3.2

BMI (kg/m²), mean ± SD	16.3 ± 2.4
Poor Dietary Compliance, n (%)	46 (32.9%)
Abdominal Pain, n (%)	88 (62.9%)
Chronic Diarrhea, n (%)	79 (56.4%)
Growth Retardation, n (%)	58 (41.4%)

Laboratory findings showed evidence of nutritional deficiencies among children with celiac disease. Mean hemoglobin was 10.7 ± 1.5 g/dL, serum calcium was 8.3 ± 0.8 mg/dL, and vitamin D level was 19.6 ± 7.4 ng/mL. The mean tissue transglutaminase antibody level was 118.5 ± 42.7 U/mL. Mean DEXA Z-score was -1.9 ± 0.9, indicating overall reduced bone mineral density. Normal BMD was observed in 52 (37.1%) children, while osteopenia and osteoporosis were identified in 61 (43.6%) and 27 (19.3%) patients, respectively.

Table 2: Laboratory and Bone Mineral Density Findings (n = 140)

Variable	Mean ± SD / n (%)
Hemoglobin (g/dL), mean ± SD	10.7 ± 1.5
Serum Calcium (mg/dL), mean ± SD	8.3 ± 0.8
Vitamin D (ng/mL), mean ± SD	19.6 ± 7.4
Tissue Transglutaminase Antibody (U/mL), mean ± SD	118.5 ± 42.7
DEXA Z-score, mean ± SD	-1.9 ± 0.9
Normal Bone Mineral Density, n (%)	52 (37.1%)
Osteopenia, n (%)	61 (43.6%)
Osteoporosis, n (%)	27 (19.3%)

Mean age was higher in the reduced BMD group (10.5 ± 3.8 vs. 8.6 ± 3.1 years; p=0.004), while BMI was significantly lower (15.6 ± 2.3 vs. 17.5 ± 2.1 kg/m²; p<0.001). Vitamin D levels were markedly lower in children with reduced BMD (16.9 ± 6.8 vs. 24.1 ± 6.2 ng/mL; p<0.001). Poor dietary compliance and growth retardation were also significantly more common in the reduced BMD group.

Table 3: Comparison between Normal and Reduced Bone Mineral Density Groups (n = 140)

Variable	Normal BMD (n=52)	Reduced BMD (n=88)	p-value
Age (years), mean ± SD	8.6 ± 3.1	10.5 ± 3.8	0.004
BMI (kg/m²), mean ± SD	17.5 ± 2.1	15.6 ± 2.3	<0.001
Vitamin D (ng/mL), mean ± SD	24.1 ± 6.2	16.9 ± 6.8	<0.001
Poor Dietary Compliance, n (%)	9 (17.3%)	37 (42.0%)	0.002
Growth Retardation, n (%)	12 (23.1%)	46 (52.3%)	<0.001

Duration of symptoms greater than 12 months was observed in 20 (74.1%) osteoporotic children compared to 43 (38.1%) non-osteoporotic patients (p=0.001). Vitamin D deficiency was highly prevalent among osteoporotic children (81.5% vs. 43.4%; p<0.001). Poor dietary compliance, growth retardation, and severe anemia were also significantly more common in children with osteoporosis, indicating the impact of prolonged disease activity and nutritional deficiencies on bone health.

Table 4: Association of Clinical Factors with Osteoporosis in Children with Celiac Disease (n = 140)

Variable	Osteoporosis Present (n=27)	Osteoporosis Absent (n=113)	p-value
Duration of Symptoms >12 months, n (%)	20 (74.1%)	43 (38.1%)	0.001
Vitamin D Deficiency, n (%)	22 (81.5%)	49 (43.4%)	<0.001
Poor Dietary Compliance, n (%)	16 (59.3%)	30 (26.5%)	0.002
Growth Retardation, n (%)	18 (66.7%)	40 (35.4%)	0.004
Severe Anemia, n (%)	14 (51.9%)	27 (23.9%)	0.006

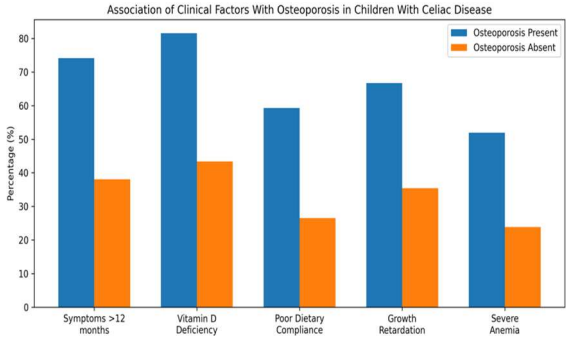

Figure 1: Association of Clinical and Nutritional Factors with Osteoporosis in Children with Celiac Disease

Logistic regression analysis identified vitamin D deficiency as the strongest predictor of reduced bone mineral density (aOR 3.42; 95% CI: 1.61–7.24; p=0.001). Growth retardation (aOR 3.11; p=0.004), poor dietary compliance (aOR 2.89; p=0.009), symptom duration >12 months (aOR 2.76; p=0.01), and BMI <16 kg/m² (aOR 2.54; p=0.01) were also significant independent predictors.

Table 5: Logistic Regression Analysis for Predictors of Reduced Bone Mineral Density (n = 140)

Variable	Adjusted OR (95% CI)	p-value
Vitamin D Deficiency	3.42 (1.61–7.24)	0.001
Poor Dietary Compliance	2.89 (1.29–6.46)	0.009
BMI <16 kg/m²	2.54 (1.18–5.49)	0.01
Growth Retardation	3.11 (1.41–6.84)	0.004
Symptom Duration >12 months	2.76 (1.25–6.09)	0.01

DISCUSSION

In this study, changes in BMD were evaluated in children with celiac disease and the study showed a high prevalence of decreased BMC including osteopenia and osteoporosis in children with celiac disease. These results show that a correlation exists between nutritional deficiencies, delayed diagnosis, non-adherence to dietary guidelines and growth retardation and therefore the bone health of children with celiac disease is compromised [18]. The mean age of the children in this study was 9.8±3.7 years and there was a slight female predominance. A significant number of cases had chronic gastrointestinal symptoms and growth retardation, a consequence of the systemic effects of chronic malabsorption. The same demographic and clinical features were observed in a previous study [19] reported that the most frequent symptoms were abdominal pain, chronic diarrhea and growth delay in children with celiac disease. The present study showed some significant nutritional deficiencies such as low level of hemoglobin, serum calcium and vitamin D. Overall, the mean DEXA Z score was -1.9 ± 0.9, suggesting a general decrease in BMD in the participants. In 43.6% of the children, osteopenia was observed and in 19.3% of children, osteoporosis was observed. The results corroborate previous studies that have identified a link between celiac disease and poor bone health. A previous study found that, in untreated pediatric CD, due to chronic nutrient malabsorption and inflammation, there was a high prevalence of osteopenia and osteoporosis [20]. The BMI and vitamin D levels were significantly lower in the children with reduced BMD than in those with normal BMD. Lower BMI may be due to chronic malnutrition and poor nutrient absorption that adversely impact bone formation and skeletal growth. Vitamin D deficiency was strongly associated with the low BMD indicating the importance of calcium and vitamin D metabolism in maintaining bone health in children. Another study showed that patients with celiac disease who have lower BMD also have lower levels of vitamin D and BMI [21].

Children with reduced BMD and kids with osteoporosis were much more likely to have poor dietary compliance. A lifelong gluten-free diet is necessary to heal the intestine, restore nutrient absorption and improve bone mineral density. If the child is not compliant, it is possible that they will still have persistent inflammation and malabsorption and keep the damage to their skeletons. Another study, also reported earlier, demonstrated impaired recovery of bone mineral density and higher risk for osteopenia in patients not following a gluten free diet [22]. Another important problem identified in this study was growth retardation which was highly correlated with both decreased BMD and osteoporosis. A chronic malabsorption and nutritional deficiencies in celiac disease can also impact on growth and skeletal maturation. Peak bone mass acquisition and growth failure is especially common in children with untreated disease for extended periods of time. Another research has previously confirmed the strong correlation between growth retardation and delayed puberty with reduced bone density in the paediatric celiac disease patient population.

Limitations

This study has several limitations. Being a single-center cross-sectional study, the findings may not be generalizable to all pediatric populations with celiac disease. The relatively small sample size may have limited the strength of subgroup analyses. Dietary compliance was partly based on patient or parent reporting, which may introduce recall and reporting bias. The study also lacked a healthy control group for direct comparison of bone mineral density values. In addition, long-term follow-up was not performed, limiting assessment of changes in bone mineral density after prolonged adherence to a gluten-free diet and nutritional supplementation.

CONCLUSION

It is concluded that children with celiac disease frequently experience reduced bone mineral density, with a high prevalence of osteopenia and osteoporosis.

Factors such as vitamin D deficiency, low body mass index, prolonged symptom duration, poor adherence to a gluten-free diet, and growth retardation were significantly associated with impaired bone health. Early diagnosis, proper nutritional management, strict dietary compliance, and regular monitoring of bone mineral density are essential to prevent long-term skeletal complications and improve growth outcomes in children with celiac disease.

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