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Bone health assessment in children with osteogenesis imperfecta from a pediatric endocrinology perspective

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ABSTRACT

Objective: Osteogenesis imperfecta (OI) is an uncommon hereditary disorder of connective tissue that results in fragile bones due to abnormalities in collagen structure. This study aimed to evaluate bone health in children with OI who were hospitalized for fracture treatment.

Materials and Methods: This retrospective observational study reviewed the records of children aged 3–18 years and diagnosed with OI and hospitalized in the pediatric orthopedics ward for fractures between May 1, 2023, and January 31, 2026. The patients' demographic characteristics, biochemical parameters, bone mineral density (BMD) Z-scores, vertebral radiographs, vitamin D levels, sun exposure, and treatment status were evaluated.

Results: A total of 37 patients participated in the study. The average age of the patients was 10.35±3.82 years, and 78.4% were male. Mean BMD Z-score was -1.44±1.61. Vertebral fractures were present in 27% of the patients. Significant differences were observed between groups stratified by vitamin D levels for age ($p = 0.020$), serum calcium ($p = 0.003$), phosphorus ($p = 0.005$), alkaline phosphatase ($p = 0.027$), parathyroid hormone ($p = 0.018$), and BMD Z-score ($p = 0.023$). Patients with vitamin D deficiency showed lower serum calcium levels and BMD Z-scores. Additionally, a statistically significant positive correlation was identified between BMD Z-score and serum calcium levels ($r=0.343$; $p=0.038$).

Conclusion: Evaluation of skeletal health in children with OI should not rely solely on BMD measurements; vertebral fractures, biochemical markers, growth, and environmental factors should also be considered. Collaboration between pediatric orthopedics and pediatric endocrinology is vital for better long-term outcomes.

Keywords: Bone mineral density, child, osteogenesis imperfecta, spinal fractures, vitamin D

Introduction

Osteogenesis imperfecta (OI) is a hereditary connective tissue disorder primarily associated with abnormalities in type I collagen. It is characterized by compromised bone integrity and heightened skeletal fragility (1). The clinical spectrum can vary widely, including low bone mineral density, recurrent long-bone fractures, vertebral deformities, short stature, skeletal anomalies, and hearing loss (2). Pathogenic variants identified in more than 20 genes today explain the genetic and clinical heterogeneity of OI and account for the significant variations in disease severity among individuals (2,3).

Recurrent fractures in children with OI may lead not only to physical morbidity but also to psychosocial difficulties due to repeated hospitalizations, immobilization, and surgical procedures (4,5). Especially in children who have orthopedic surgery because of fractures, issues like delayed mobilization, social withdrawal from peers, and missing school greatly reduce quality of life. Therefore, the main goal in managing OI is to reduce fracture frequency, alleviate bone pain, maintain bone health, and enable children to move safely and participate in daily activities (6). Current management strategies do not provide a definitive cure but include multidisciplinary approaches, such as antiresorptive therapies (e.g., bisphosphonates, especially intravenous (IV) pamidronate) to decrease fracture frequency and bone pain, along with physical therapy, rehabilitation, and orthopedic surgery when needed (7). However, in clinical practice, delaying or irregularly administering antiresorptive therapies after a fracture can result in insufficient gains in bone mineral density and a heightened risk of new fractures. This situation calls for increased awareness of bone health monitoring among both families and physicians practicing in pediatric orthopedics and pediatrics (8).

Although gene therapy and stem cell-based approaches have shown promise as long-term treatment options in

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recent years, current clinical practice for maintaining bone health in children with OI still depends on regular monitoring, suitable antiresorptive therapy, sufficient calcium (Ca) and vitamin D supplementation, sunlight exposure, physical therapy, rehabilitation, orthopedic surgery, multidisciplinary follow-up, and early mobilization strategies (8). In this context, systematically evaluating bone metabolism in children with OI who have had surgery due to fractures is crucial for ensuring continued treatment and identifying risk factors (9). This study aimed to retrospectively evaluate children with OI hospitalized for fractures in the pediatric orthopedics clinic from a pediatric endocrinology perspective. By analyzing patients' bone mineral density, vertebral radiographs, antiresorptive treatment status, biochemical markers of bone metabolism, serum vitamin D levels, sun exposure, and the number of fractures, the study aimed to raise clinical awareness of the need for bone health monitoring after fractures. Another objective of the study was to contribute to follow-up approaches that support early and safe mobilization of children with OI, helping them adapt to social life and their peer environment.

Materials and Methods

This study was conducted as a retrospective observational study. The hospital records of 48 pediatric patients aged 3–18 years with a diagnosis of OI who were hospitalized and treated at the Ankara Bilkent City Hospital pediatric orthopedics clinic for fractures between May 1, 2023, and January 31, 2026, were reviewed. Consecutive patients meeting the study criteria during the study period were included in the analysis. The legal guardians of the patients were fully informed about the study, and their consent was obtained. After collecting demographic data on the patients, concurrent clinical and laboratory data were examined thoroughly. The laboratory tests evaluated included: serum Ca, corrected Ca, phosphorus (P), magnesium (Mg), alkaline phosphatase (ALP), vitamin D, parathyroid hormone (PTH), albumin, urea, and creatinine. The patients' biochemical parameters were obtained from measurements taken within the three months prior to their hospitalization for the fracture. All biochemical and densitometric measurements were obtained during the post-fracture follow-up period and not during the acute trauma evaluation. The corrected Ca (mg/dL) value was calculated using the following formula: Corrected Ca = total Ca + 0.8 × (4 – albumin) (10). Bone mineral density (BMD) values collected within the last six months were analyzed. Lumbar spine bone mineral density (L1–L4) was assessed by dual-energy X-ray absorptiometry (DXA), and Z-scores were calculated based on the patients' gender and age. Additionally, vertebral radiographs taken within the past six months were reviewed by an experienced pediatric orthopedist for vertebral compression fractures. Genetic test results indicating the patients' OI subtype were obtained from hospital records. Records were also used to assess whether patients received regular IV pamidronate therapy, Ca and vitamin D supplements, and their sun exposure history. Regular IV pamidronate therapy was defined, according to medical records, as receiving scheduled antiresorptive treatment without interruption during the planned follow-up period. Treatment adherence was evaluated using outpatient follow-up notes and categorized as regular or irregular based on physician documentation. Sun exposure history was assessed from patient records and classified based on the presence of regular daytime outdoor exposure reported by caregivers. Anthropometric measurements were conducted by the same trained nurse using the same equipment to ensure consistency across all patients. Body weight was measured with a digital scale while patients were lightly clothed and barefoot. For children able to stand, height was measured with a stadiometer while standing. For patients unable to stand or with limited mobility, height was measured as the distance from the top of the head to the heels using the same measuring tape, with the patient in a supine position and muscles kept taut. The standard deviation score (SDS) values and BMD Z-scores for anthropometric measurements were calculated using ChildMetrics (11). Additionally, patients were assessed for vitamin D levels as deficient, insufficient, or normal (12). Patients with missing data in hospital records, those admitted for reasons other than fracture and followed up, and participants who did not give consent were excluded from the study.

Statistical analysis

Statistical analyses were performed utilizing SPSS software (Version 26.0, IBM Corp., Armonk, NY, USA). The distribution of continuous variables was evaluated through the Shapiro–Wilk test. For variables not normally distributed, the Kruskal–Wallis test was used to compare the three groups. When significant differences were found, pairwise comparisons were performed using the Dunn–Bonferroni post hoc test, and a Bonferroni correction was applied to address multiple comparisons. The Mann–Whitney U test was used to compare two groups. Categorical variables were analyzed using the chi-square or Fisher's exact test. Relationships between variables were assessed with Spearman's correlation analysis. Multivariable linear regression analysis was performed to identify variables independently associated with BMD Z-scores. Serum total calcium, PTH, and 25(OH)D levels were included in the multivariable model a priori because of their established clinical relevance to bone metabolism. Regression assumptions, including linearity, normality of residuals, and multicollinearity, were evaluated before model construction. A p-value of <0.050 was deemed statistically significant.

Results

Thirty-seven patients who met the study criteria were included in the analysis. According to the Tanner stage, 45.9% of patients were prepubertal, and 54.1% were pubertal. The mean age of the patients was 10.35±3.82 years, with an age range of 3.8 to 17.1 years. A total of 78.4% (n=29) of the patients were male, and 21.6% (n=8) were female. The mean height SDS was -2.02 ± 0.96, the weight SDS was -2.00±1.02, and the body mass index (BMI) SDS was -1.23±1.12. In biochemical evaluation, the mean serum total Ca was 9.46±0.47 mg/dL, corrected Ca was 9.42±0.39 mg/dL, P was 4.64±0.59 mg/dL, Mg was 1.85±0.16 mg/dL, ALP was 194.95±74.89 U/L, PTH was 45.24±15.41 pg/mL, and 25(OH) vitamin D level was 45.92±17.22 nmol/L. The mean BMD Z-score was –1.44±1.61 (Table I).

When patients were analyzed by genetic subtype, type 1 OI associated with a heterozygous COL1A1 mutation was identified in 15 patients (40.5%). The distribution of other genetic subtypes is shown in Figure 1.

Table I: Demographic characteristics and laboratory data for patients (n=37)

Variables	Values*	Reference Values
Age (years)	10.35 ± 3.82 (3.80-17.10)	-
Height SDS	–2.02 ± 0.96 (–4.70-–0.50)	-2< N <2
Weight SDS	–2.00 ± 1.02 (–4.80-–0.10)	-2< N <2
BMI SDS	–1.23 ± 1.12 (–4.00-0.90)	-2< N <2
Ca (mg/dL)	9.46 ± 0.47 (8.80-10.30)	8.5-10.5
Corrected Ca (mg/dL)	9.42 ± 0.39 (8.90-10.10)	8.5-10.5
Phosphorus (mg/dL)	4.64 ± 0.59 (2.90-5.40)	4-6.8
Magnesium (mg/dL)	1.85 ± 0.16 (1.50-2.10)	1.7-2.2
ALP (IU/L)	194.95 ± 74.89 (104.00-354.00)	150-400
PTH (pg/mL)	45.24 ± 15.41 (19.00-79.00)	15-65
Vitamin D (nmol/L)	45.92 ± 17.22 (15.00-90.00)	50-100
BMD Z-score	–1.44 ± 1.61 (–3.90-1.80)	>-2

***:** *mean±SD(min-max),* ***SDS:** standard deviation score,* ***BMI:** body mass index,* ***Ca:** calcium,* ***ALP:** alkaline phosphatase,* ***PTH:** parathyroid hormone,* ***BMD:** bone mineral density.*

Table II: Comparison of patients based on their vitamin D levels

Variable	Deficiency (<30 nmol/L)*	Insufficiency (30–50 nmol/L)*	Normal (>50 nmol/L)*	p†
Total number of patients	7	16	14	-
Age (years)	8.24±3.65	12.21±3.39	9.28±3.64	0.020
Height SDS	–1.67±0.46	–1.69±0.71	–2.58±1.16	0.086
Weight SDS	–1.89±0.36	–1.66±0.90	–2.45±1.23	0.072
BMI SDS	–1.51±0.86	–1.04±1.20	–1.31±1.18	0.575
Ca (mg/dL)	8.94±0.34	9.46±0.27	9.73±0.50	0.003
Corrected Ca (mg/dL)	9.16±0.29	9.34±0.25	9.63±0.46	0.029
Phosphorus (mg/dL)	4.00±0.80	4.64±0.42	4.96±0.35	0.005
Magnesium (mg/dL)	1.84±0.21	1.83±0.12	1.89±0.17	0.367
ALP (IU/L)	257.6±75.4	194.6±69.6	164.0±64.6	0.027
PTH (pg/mL)	59.1±11.5	42.4±13.7	41.6±15.9	0.018
BMD Z-score	–2.74±0.33	–1.22±1.59	–1.04±1.74	0.023

***:** *mean±SD,* **†:** *Kruskal Wallis test,* ***SDS:** standard deviation score,* ***BMI:** body mass index,* ***Ca:** calcium,* ***ALP:** alkaline phosphatase,* ***PTH:** parathyroid hormone,* ***BMD:** bone mineral density*

Regarding vitamin D levels, 18.9% of patients had deficiency (<30 nmol/L), 43.2% had insufficiency (30–50 nmol/L), and 37.8% had normal levels (>50 nmol/L). Significant differences were observed in age (p=0.020), serum Ca (p=0.003), corrected Ca (p=0.029), P (p=0.005), ALP (p=0.027), PTH (p=0.018), and BMD Z-score (p=0.023). No statistically significant differences were detected for height SDS (p = 0.086), weight SDS (p = 0.072), BMI SDS (p = 0.575), or Mg levels (p = 0.367) (Table II).

In post-hoc Dunn–Bonferroni analyses, patients with vitamin D deficiency had significantly lower serum Ca and BMD Z-scores, and higher PTH levels, compared with patients with vitamin D insufficiency and normal vitamin D levels. In addition, phosphorus and ALP differed significantly only between the vitamin D deficiency and normal vitamin D groups. No Bonferroni-corrected significant differences were observed between the insufficiency and normal vitamin D groups (Table III).

Table III: Results of the post-hoc Dunn-Bonferroni analysis based on patients' vitamin D levels.

Variable	Corrected p
Age	
<30 vs 30–50 nmol/L	0.027
<30 vs >50 nmol/L	0.488
30–50 vs >50 nmol/L	0.019
Ca	
<30 vs 30–50 nmol/L	0.005
<30 vs >50 nmol/L	0.001
30–50 vs >50 nmol/L	0.166
Corrected Ca	
<30 vs 30–50 nmol/L	0.027
<30 vs >50 nmol/L	0.038
30–50 vs >50 nmol/L	0.142
Phosphorus	
<30 vs 30–50 nmol/L	0.039
<30 vs >50 nmol/L	0.002
30–50 vs >50 nmol/L	0.052
ALP	
<30 vs 30–50 nmol/L	0.065
<30 vs >50 nmol/L	0.007
30–50 vs >50 nmol/L	0.240
PTH	
<30 vs 30–50 nmol/L	0.006
<30 vs >50 nmol/L	0.012
30–50 vs >50 nmol/L	0.697
BMD Z-score	
<30 vs 30–50 nmol/L	0.012
<30 vs >50 nmol/L	0.010
30–50 vs >50 nmol/L	0.790

***Ca:** calcium,* ***ALP:** alkaline phosphatase,* ***PTH:** parathyroid hormone,* ***BMD:** bone mineral density.* ***Bolded values:** Below the Bonferroni-corrected significance level (p < 0.0167)*

When the relationships between vitamin D groups and categorical variables were evaluated, significant differences were observed among the groups concerning vitamin D treatment status, with treatment rates of 57.1% (4/7), 87.5% (14/16), and 100% (14/14) in the deficiency, insufficiency, and normal groups, respectively (p=0.025), and treatment regimen, with regular treatment rates of 0% (0/7), 56.3% (9/16), and 78.6% (11/14), respectively (p=0.003). On the other hand, no significant association was observed between vitamin D groups and Ca treatment [14.3% (1/7), 50.0% (8/16), and 64.3% (9/14), respectively; p=0.114], sun exposure [42.9% (3/7), 68.8% (11/16), and 78.6% (11/14), respectively; p=0.273], the presence of vertebral fractures [28.6% (2/7), 31.3% (5/16), and 21.4% (3/14), respectively; p = 0.887], Tanner stage [pubertal: 28.6% (2/7), 75.0% (12/16), and 42.9% (6/14), respectively; p=0.086], or gender [male: 85.7% (6/7), 87.5% (14/16), and 64.3% (9/14), respectively; p=0.343]. When evaluating patients for vertebral fractures, 27.0% (n=10) of the cohort were found to have them. There were no statistically significant differences between patients with and without vertebral fractures in terms of age (p= 0.130), height SDS (p=0.229), weight SDS (p=0.389), BMI SDS (p=0.906), total Ca (p = 0.933), corrected Ca (p=0.602), P (p=0.933), Mg (p=0.674), ALP (p=0.933), PTH (p =0.511), or vitamin D levels (p=0.319). Although BMD Z-scores were lower in patients with vertebral fractures, the difference

Table IV: Comparison of patients based on the presence or absence of vertebral fractures

Variable	Vertebral fracture absent	Vertebral fracture present	p
Total number of patients	27	10	-
Age (years)*	9.79 ± 3.99	11.87 ± 3.00	0.130
Height SDS (-2< N<2)*	–2.17 ± 1.01	–1.63 ± 0.74	0.229
Weight SDS (-2< N<2)*	–2.08 ± 1.10	–1.79 ± 0.76	0.389
BMI SDS (-2< N<2)*	–1.24 ± 1.26	–1.20 ± 0.68	0.906
Ca (mg/dL) (N: 8.5-10.5)*	9.49 ± 0.53	9.39 ± 0.26	0.933
Corrected Ca (mg/dL) (N: 8.5-10.5)*	9.45 ± 0.43	9.32 ± 0.26	0.602
Phosphorus (mg/dL) (N: 4-6.8)*	4.61 ± 0.66	4.73 ± 0.32	0.933
Magnesium (mg/dL) (N: 1.7-2.2)*	1.85 ± 0.15	1.86 ± 0.19	0.674
ALP (IU/L) (N: 150-400)*	193.9 ± 74.7	197.8 ± 79.4	0.933
PTH (pg/mL) (N: 15-65)*	46.4 ± 15.2	42.1 ± 16.3	0.511
BMD Z-score (N: >-2)*	–1.28 ± 1.64	–1.86 ± 1.51	0.229
Vitamin D (nmol/L) (N: 50-100)*	47.1 ± 18.8	42.6 ± 12.0	0.319
Gender†			
Male	20 (69.0)	9 (31.0)	0.404
Female	7 (87.5)	1 (12.5)	
Tanner stage†			
Prepubertal	15 (88.2)	2 (11.8)	0.073
Pubertal	12 (60.0)	8 (40.0)	
Calcium treatment†			
Present	16 (84.2)	3 (15.8)	0.151
Absent	11 (61.1)	7 (38.9)	
Vitamin D treatment†			
Present	5 (100)	0 (0)	0.295
Absent	22 (68.8)	10 (31.3)	
Sun exposure†			
Present	7 (58.3)	5 (41.7)	0.240
Absent	20 (80.0)	5 (20.0)	
Pamidronat treatment regularity†			
Regular	10 (58.8)	7 (41.2)	0.136
Irregular	17 (85.0)	3 (15.0)	

***:** mean±SD (Mann–Whitney U test), **†:** n(%) (Fisher's exact test), **SDS:** standard deviation score, **BMI:** body mass index, **Ca:** calcium, **mg:** milligrams, **dL:** deciliters, **N:** normal, **ALP:** alkaline phosphatase, **PTH:** parathyroid hormone, **nmol:** nanomoles, **L:** liters, **BMD:** bone mineral density*

Table V: Correlation analysis results

Variable / Model Correlation analysis	r	p
BMD Z-score – Total Ca	0.343	0.038
BMD Z-score – Corrected Ca	0.313	0.059
BMD Z-score – P	0.274	0.101
BMD Z-score – Mg	0.264	0.114
BMD Z-score – ALP	–0.191	0.258
BMD Z-score – PTH	–0.233	0.166
BMD Z-score – Vitamin D	0.274	0.100
BMD Z-score – Age	–0.061	0.718
BMD Z-score – Height SDS	–0.001	0.997
BMD Z-score – Weight SDS	0.067	0.693
BMD Z-score – BMI SDS	0.093	0.586
P – PTH	–0.484	0.002
Vitamin D – Total Ca	0.457	0.005
Vitamin D – Corrected Ca	0.367	0.026

***r:** Spearman's rank correlation coefficient, **SDS:** standard deviation score, **BMI:** body mass index, **Ca:** calcium, **P:** phosphorus, **Mg:** magnesium, **ALP:** alkaline phosphatase, **PTH:** parathyroid hormone, **BMD:** bone mineral density*

did not reach statistical significance (p=0.229). A total of 48.6% of patients were receiving Ca therapy, while 86.5% were receiving vitamin D therapy. A history of regular sun exposure was reported in 67.6% of cases, and treatment adherence was observed in 54.1%. Similarly, there were no significant differences between the groups concerning gender (p=0.404), Tanner stage (p=0.073), Ca treatment status (p=0.151), vitamin D treatment status (p=0.295), sun exposure (p=0.240), or pamidronate treatment regimen (p= 0.136) (Table IV).

Table VI: Multiple linear regression analysis predicting BMD Z-score

Predictor	B	SE B	β	t	p	95% CI for B
Total calcium	1.014	0.634	0.295	1.599	0.119	–0.276 to 2.305
PTH	–0.014	0.018	–0.138	–0.812	0.422	–0.050 to 0.022
Vitamin D	0.007	0.018	0.074	0.387	0.701	–0.029 to 0.043

*R^2=0.158; adjusted R^2=0.081; F(3, 33)=2.065; p=0.124. **B:** unstandardized regression coefficient; **SE B:** standard error; **β:** standardized regression coefficient; **CI:** confidence interval; **PTH:** parathyroid hormone*

Correlation analysis results are summarized in Table V. A statistically significant positive correlation was observed between BMD Z-score and serum total calcium levels (r=0.343; p=0.038). In addition, serum phosphorus was negatively correlated with PTH (r=–0.484; p=0.002) and positively correlated with vitamin D (r=0.454; p=0.005). Vitamin D was also positively correlated with total calcium (r =0.457; p =0.005) and corrected calcium levels (r=0.367; p =0.026) (Table V).

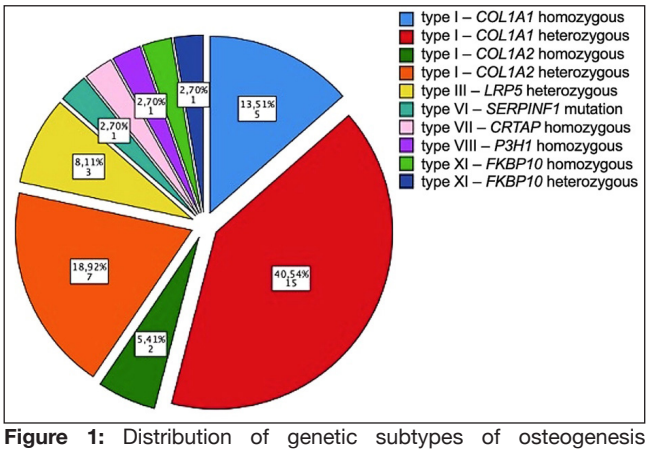

Figure 1: Distribution of genetic subtypes of osteogenesis imperfecta in the study population.

Multiple linear regression analysis results are presented in Table VI. The overall regression model was not statistically significant (R^2=0.158, adjusted R^2 =0.081; F[3,33] = 2.065; p =0.124). Serum total calcium (B=1.014; p=0.119), PTH (B = –0.014; p=0.422), and vitamin D (B=0.007; p=0.701) were not independently associated with BMD Z-score (Table VI).

Discussion

This study examines the bone health of pediatric patients diagnosed with OI who presented to a pediatric orthopedic clinic for fractures from a pediatric endocrinology perspective. Our results support the concept that reduced BMD and the relatively high frequency of vertebral fractures in OI mainly reflect the underlying abnormalities of the bone matrix, with mechanical trauma serving a secondary role (13). Additionally, disparities in access to antiresorptive therapy and variations in treatment continuity have facilitated a comparative analysis of the disease's natural progression versus the effects of therapeutic interventions (14,15).

Growth retardation, low BMD, and a high rate of vertebral fractures (27%) are significant findings in the study group (16). Recent longitudinal studies indicate that the annual incidence of new vertebral fractures or deformities in children with OI ranges from about 10% to 25%, is higher in severe phenotypes, and is notably decreased by bisphosphonate therapy (9,13). Vitamin D deficiency and low treatment adherence highlight the importance of modifiable factors affecting bone health (17). However, no notable link was found between biochemical parameters and the anthropometric indicators measured alongside BMD (18). This implies that BMD alone might be limited in its ability to reflect disease severity and metabolic status in OI (13,19). A comparison between patients who are able to regularly receive antiresorptive therapy and those who are unable to do so may suggest clinical differences in fracture burden and vertebral involvement, independent of the absolute change in BMD (13). This observation emphasizes that access to treatment and continuity of care are at least as vital as pharmacological efficacy in the management of OI (9,20). It is anticipated that the increase in BMD in patients with OI is less pronounced than in secondary osteoporosis, given that the underlying pathology involves deterioration in bone quality rather than bone mass (13). Consequently, even if bisphosphonate therapy yields only a modest increase in BMD, it is well established that clinical benefits predominantly include reduced pain, enhanced mobility, and improved functional capacity (13,21).

The fact that the biochemical parameters obtained in our study mainly fall within reference ranges supports the idea that the risk of fracture primarily stems from primary osteoporosis rather than secondary metabolic disorders (9). Reviewing the hospital records of patients who came to our center due to fractures revealed that many of these patients had already been receiving treatment and follow-up. However, the frequency and consistency of their follow-up varied. This may partly explain why biochemical parameters appeared within reference ranges at the time of assessment (22). Nevertheless, the fluctuations in vitamin D levels and sun exposure emphasize the role of environmental and metabolic factors in fracture risk, especially when access to treatment is limited (17,18).

The lack of major differences in biochemical, clinical, and densitometric parameters between patients with and without vertebral fractures indicates that vertebral fractures often progress quietly without obvious symptoms (23). This supports the idea that focusing only on symptomatic fractures in children with OI is insufficient and highlights the importance of regular radiological follow-up (13,23). Early identification of vertebral deformities is crucial not only for assessing the disease burden but also for optimizing the timing of antiresorptive therapy (7).

Bisphosphonates reduce bone resorption primarily by suppressing osteoclast-mediated bone turnover. They may also increase osteoblastic activity, which could indirectly speed up healing in osteoporosis (9). However, because osteoclastic activity is important during fracture healing—especially in the remodeling phase—it is more sensible to plan treatment at least 4 weeks after a fracture rather than immediately after (9). This advice does not mean treatment should be completely delayed; instead, it emphasizes the importance of personalized planning that considers fracture healing processes (20). Since hospital stays due to fractures can interrupt antiresorptive therapy, this highlights the need for coordinated follow-up care between pediatric orthopedics and pediatric endocrinology (9).

In the long-term follow-up of children with OI, it is important to assess not only the number of fractures and BMD measurements but also clinical parameters such as bone pain, functional capacity, and daily activity levels. Regularly monitoring these factors throughout clinical follow-up provides a more complete understanding of treatment effectiveness and helps prevent early functional decline (9,13). Furthermore, integrating personalized physical therapy programs and lifestyle modifications into the treatment plan is crucial for boosting bone health and improving patients' quality of life (4,6).

Given the genetic heterogeneity and the varying clinical courses of OI subtypes, the importance of a multidisciplinary approach becomes even clearer. Collaboration among pediatric endocrinologists, orthopedic surgeons, and rehabilitation specialists plays a vital role in reducing fracture risk, enhancing treatment adherence, and ensuring

long-term functional improvements (24). In this context, future studies exploring genotype-phenotype relationships and assessing subtype-specific treatment responses will help develop more targeted strategies for OI management.

Limitations

This study has certain limitations. The relatively small sample size may have limited the statistical power of subgroup analyses and reduced the ability to detect weaker associations. Because of the limited number of cases with OI subtypes other than Type 1 OI, meaningful comparisons of osteoporosis diagnostic parameters might not have been possible in these groups; differences related to genetic variation are known (2,3), and studies with larger patient groups could help clarify these differences more effectively.

Another limitation of the study is that although serum Ca, corrected Ca, P, Mg, and ALP levels were assessed, these parameters could not be analyzed separately using age- and puberty-specific reference ranges. Since ALP levels in childhood are linked to growth and bone turnover rates, not assessing ALP isoenzymes (e.g., bone-specific ALP) may have made it difficult to clearly identify bone-related activity. Additionally, because ALP is released from the bone, liver, intestines, and other tissues, this could restrict the accuracy of total ALP levels in reflecting bone metabolism. Nevertheless, the inclusion of recent biochemical data, along with densitometric and radiological records, can be seen as a strength of the study (25).

Conclusion

Evaluation of bone health in children with OI should not rely solely on BMD measurements; it should also include vertebral fractures, biochemical parameters, growth data, environmental factors, and access to treatment. The goals of management extend beyond improving BMD and also include reducing pain, improving function, and supporting quality of life. Incorporating a pediatric endocrinology approach into pediatric orthopedic care and ensuring continuous access to antiresorptive therapy will help children with OI lead more active and sustainable lives.

Ethics committee approval

This study was conducted in accordance with the Helsinki Declaration Principles. The study was approved by Ankara Bilkent City Hospital (04.03.2026, reference number: 2-26-2063).

Contribution of the authors

Study conception and design: BT; data collection: BT, NEY; analysis and interpretation of results: BT, NEY; draft manuscript preparation: BT, NEY. All authors reviewed the results and approved the final version of the article.

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Conflict of interest

The authors declare that there is no conflict of interest.

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