

Association Between Vitamin D Deficiency and Delayed Tooth Eruption in Children

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Abstract:

Background: Tooth eruption is a critical developmental milestone in children, influenced by genetic, nutritional, and endocrine factors. Vitamin D plays a central role in calcium and phosphorus metabolism which is vital for mineralization of bone and teeth. This study examines the association between Vitamin D deficiency and delayed tooth eruption in children.

Objective: To determine whether serum Vitamin D levels are associated with the timing of tooth eruption in children aged 6–12 years.

Methods: A cross-sectional observational study was conducted among 150 children attending the outpatient department at Shyam Shah Medical College, Rewa. Eruption status was assessed clinically and correlated with serum 25-hydroxyvitamin D levels. Delayed eruption was defined using standardized periodontal eruption charts and age-matched norms. Serum Vitamin D levels were categorized as sufficient (>30 ng/mL), insufficient (21–30 ng/mL), and deficient (<20 ng/mL).

Results: Of the 150 subjects, 62 (41%) had Vitamin D deficiency, 45 (30%) had insufficiency, and 43 (29%) had sufficient levels. Delayed tooth eruption was observed in 48 children (32%). A significant association was found between Vitamin D deficiency and delayed eruption ($p < 0.01$). Children with deficient Vitamin D had 3.2 times higher odds of delayed tooth eruption compared to those with sufficient levels.

Conclusion: Vitamin D deficiency is significantly associated with delayed tooth eruption in children. Early identification and correction of Vitamin D deficiency may support normal dental developmental patterns.

Keywords: Vitamin D deficiency, Tooth eruption, Children, Delayed eruption, Serum 25-hydroxyvitamin D.

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Introduction

Tooth eruption is a dynamic, multifactorial process that signifies dental development and maturity in pediatric populations. Normal eruption patterns ensure functional occlusion, esthetics, and overall oral health. Disruptions in this process can have long-term consequences including malocclusion, speech difficulties, masticatory inefficiency, and psychological impacts affecting a child's quality of life.

The timing of tooth eruption is influenced by a complex interaction of genetic, environmental, nutritional, and hormonal factors. Systemic conditions such as endocrine disorders, metabolic bone diseases, and nutritional deficiencies have been shown to alter normal eruption patterns. Among nutritional factors, adequate intake of calcium, phosphorus, and Vitamin D is considered crucial for proper skeletal and dental development during childhood.

Vitamin D, a secosteroid hormone, plays a pivotal role in regulating calcium and phosphorus homeostasis. It enhances intestinal absorption of calcium and promotes mineralization of bone and dental tissues. Inadequate Vitamin D levels can disrupt these processes, leading to compromised bone density and altered dentoalveolar development. Deficiency of Vitamin D has traditionally been associated with skeletal disorders such as rickets and osteomalacia; however, increasing evidence suggests that it also affects oral tissues, including enamel formation, dentin mineralization, and tooth eruption.

From a biological perspective, Vitamin D influences the differentiation and function of osteoblasts, odontoblasts, and ameloblasts, which are essential for tooth development and eruption. The Vitamin D receptor has been identified in dental tissues, indicating a direct regulatory role in odontogenesis.

Insufficient Vitamin D during critical growth periods may therefore delay the eruptive process by impairing alveolar bone remodeling and tooth movement.

In recent years, pediatric Vitamin D deficiency has emerged as a significant public health concern, particularly in developing countries. Factors such as limited sunlight exposure, dietary inadequacy, urban lifestyle, and increased screen time have contributed to widespread hypovitaminosis D among children. In India, multiple studies have reported a high prevalence of Vitamin D deficiency even among otherwise healthy pediatric populations.

Despite growing evidence regarding the systemic and oral health effects of Vitamin D, its specific association with the timing of tooth eruption remains underexplored, especially in Indian children. Most existing studies have focused on dental caries and enamel defects, with limited emphasis on eruption patterns as a developmental outcome. Understanding this association is important, as delayed tooth eruption may serve as an early clinical indicator of underlying nutritional deficiencies.

Therefore, the present study was undertaken to evaluate the relationship between serum Vitamin D levels and delayed tooth eruption in children. By addressing this gap, the study aims to contribute to existing pediatric and dental literature and highlight the importance of early nutritional assessment in promoting optimal oral and overall development in children.

Materials and Methods

Study Design and Population: A cross-sectional study was conducted from January 2024 to October 2025 at Shyam Shah Medical College, Rewa. Ethics approval was obtained from the institutional review board. A total of 150 children aged between 6 and 12 years were included in the study.

Inclusion Criteria

- Children aged 6–12 years
- No history of chronic systemic diseases
- No medications affecting bone metabolism

Exclusion Criteria

- Congenital dental anomalies
- Endocrine disorders (e.g., hypothyroidism)
- History of trauma to jaws

Clinical Evaluation: Tooth eruption status was determined using standardized charts, assessing the presence or absence of permanent teeth expected for chronological age. Delay was defined when eruption status did not match age-specific norms.

Biochemical Analysis: Venous blood samples were collected. Serum 25-hydroxyvitamin D was estimated using chemiluminescence immunoassay. Levels were categorized per Endocrine Society guidelines:

Deficient: <20 ng/mL.

Insufficient: 21–30 ng/mL.

Sufficient: >30 ng/mL.

Statistical Analysis: Data were analyzed using SPSS v25. Chi-square test determined associations. Logistic regression was used to calculate odds ratios. A *p-value* < 0.05 was considered significant.

Results

A total of 150 children aged between 6 and 12 years were included in the study. The mean age of the participants was 9.2 ± 1.8 years, indicating a balanced representation across middle childhood. Of the total sample, 78 children (52%) were males and 72 (48%) were females, demonstrating an almost equal gender distribution and minimizing gender-related bias in the analysis.

Assessment of serum Vitamin D levels revealed a high prevalence of hypovitaminosis D among the study population. Vitamin D deficiency was observed in 62 children (41.3%), while 45 children (30.0%) had insufficient levels. Only 43 children (28.7%) exhibited sufficient serum Vitamin D concentrations, highlighting the widespread nature of Vitamin D inadequacy in the pediatric age group.

Evaluation of tooth eruption status showed that delayed eruption was present in 48 children (32%), whereas the majority of participants, 102 children (68%), demonstrated normal eruption patterns appropriate for their chronological age. This indicates that nearly one-third of the study population experienced delayed dental eruption.

A statistically significant association was found between Vitamin D status and tooth eruption pattern (Chi-square test, $p < 0.01$). Among children with Vitamin D deficiency, more than half (52%) exhibited delayed tooth eruption, compared to 22% in the insufficient group and only 14% in the sufficient group. Conversely, normal eruption was most commonly observed in children with sufficient Vitamin D levels (86%).

Logistic regression analysis further demonstrated that children with Vitamin D deficiency had 3.2 times higher odds of delayed tooth eruption compared to those with sufficient Vitamin D levels (OR = 3.2; 95% CI: 1.8–5.6). These findings clearly indicate a strong and clinically relevant association between low Vitamin D levels and delayed tooth eruption in children.

Table 1: Demographic Characteristics of the Study Population (n = 150)

Variable	Number (%)
Age (years)	
6–8	52 (34.7%)
9–10	54 (36.0%)
11–12	44 (29.3%)
Mean Age ± SD	9.2 ± 1.8
Gender	
Male	78 (52.0%)
Female	72 (48.0%)

This table summarizes the age and gender distribution of the study participants. The mean age was 9.2 ± 1.8 years, with an almost equal representation of male and female children, indicating a balanced demographic profile.

Table 2: Distribution of Serum Vitamin D Levels

Vitamin D Status	Serum 25(OH)D Level	Number (%)
Deficient	< 20 ng/mL	62 (41.3%)
Insufficient	21–30 ng/mL	45 (30.0%)
Sufficient	> 30 ng/mL	43 (28.7%)
Total	—	150 (100%)

Table 2 shows the distribution of serum 25-hydroxyvitamin D levels among the children. A high prevalence of Vitamin D deficiency and insufficiency was observed, with less than one-third of participants having sufficient Vitamin D levels.

Table 3: Tooth Eruption Status Among Study Participants

Tooth Eruption Status	Number (%)
Normal eruption	102 (68.0%)
Delayed eruption	48 (32.0%)
Total	150 (100%)

This table presents the distribution of tooth eruption status in the study population. Delayed tooth eruption was observed in nearly one-third of children, while the majority exhibited age-appropriate normal eruption patterns.

Table 4: Association Between Vitamin D Status and Tooth Eruption

Vitamin D Status	Delayed Eruption n (%)	Normal Eruption n (%)	Total
Deficient	32 (51.6%)	30 (48.4%)	62
Insufficient	10 (22.2%)	35 (77.8%)	45
Sufficient	6 (14.0%)	37 (86.0%)	43
Total	48	102	150

test: $p < 0.01$ (statistically significant)

Table 4 illustrates the relationship between Vitamin D status and tooth eruption pattern. Delayed eruption was most frequently observed among Vitamin D-deficient children, and the association was statistically significant (Chi-square test, $p < 0.01$).

Table 5: Logistic Regression Analysis for Delayed Tooth Eruption

Variable	Odds Ratio (OR)	95% Confidence Interval	p-value
Vitamin D Deficiency	3.2	1.8 – 5.6	< 0.01
Vitamin D Insufficiency	1.6	0.8 – 3.2	0.12
Age	1.1	0.9 – 1.4	0.21
Gender	0.9	0.5 – 1.7	0.74

This table presents the results of logistic regression analysis assessing predictors of delayed tooth eruption. Vitamin D deficiency emerged as a significant risk factor, with deficient children having more than threefold higher odds of delayed eruption.

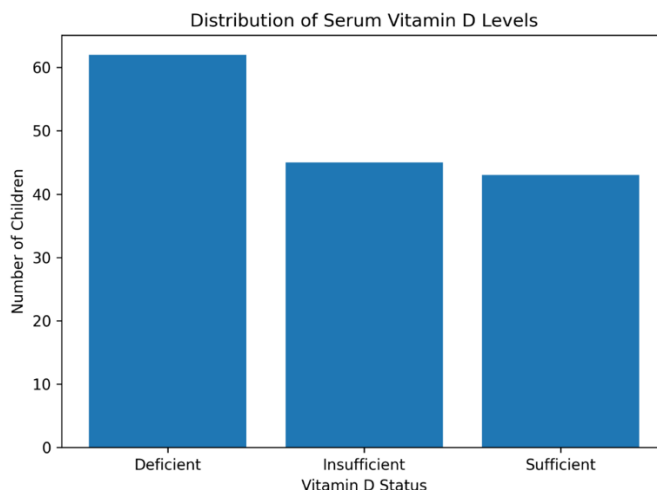


Figure 1: Distribution of serum 25-hydroxyvitamin D levels among the study population showing a high prevalence of deficiency.

This figure depicts the distribution of serum Vitamin D status among the study population. Vitamin D deficiency constituted the largest proportion, highlighting widespread hypovitaminosis D among child.

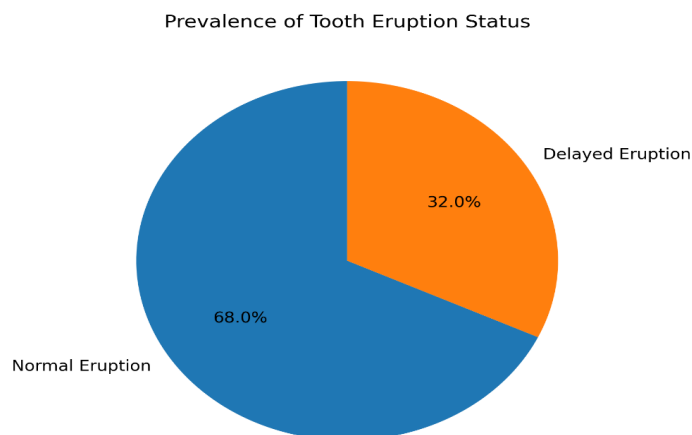


Figure 2: Pie chart depicting the prevalence of normal and delayed tooth eruption among children

The pie chart demonstrates the proportion of children with normal and delayed tooth eruption. Delayed eruption was present in 32% of participants, indicating a substantial prevalence

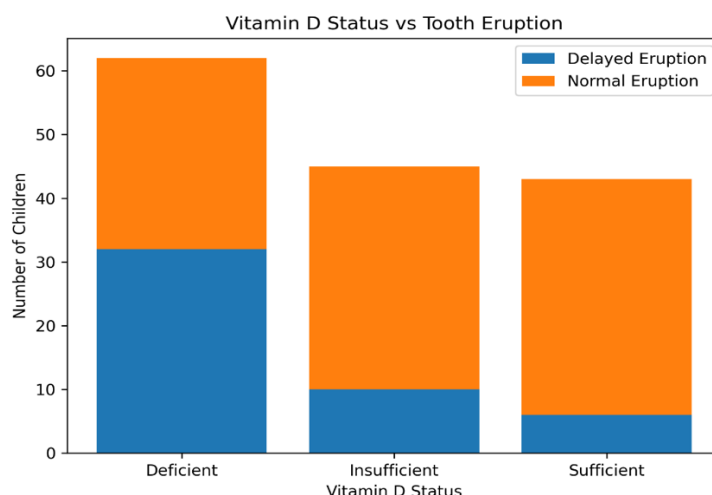


Figure 3: Bar diagram showing the relationship between Vitamin D status and tooth eruption pattern, with delayed eruption most common in deficient children

This bar diagram illustrates the association between Vitamin D status and tooth eruption. Delayed tooth eruption was most common among Vitamin D-deficient children and decreased progressively with improving Vitamin D levels

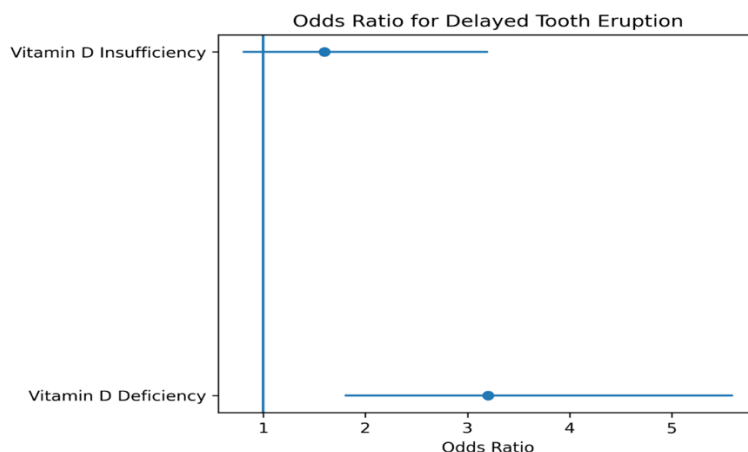


Figure 4: Forest plot illustrating odds ratios for delayed tooth eruption according to Vitamin D status

The forest plot displays the odds ratios for delayed tooth eruption across Vitamin D categories. Vitamin D deficiency showed a significantly increased risk of delayed eruption compared to sufficient Vitamin D status.

Discussion

This study investigated the association between serum Vitamin D levels and delayed tooth eruption in a pediatric population aged 6–12 years. Our results showed a significant association between Vitamin D deficiency and delayed eruption of permanent teeth, with deficient children exhibiting a three-fold higher risk of delayed eruption compared to children with sufficient Vitamin D. This finding highlights the potential role of Vitamin D in dental development, extending beyond its well-established function in systemic bone metabolism.

Comparison with Previous Studies: Vitamin D deficiency has been extensively associated with skeletal disorders such as rickets and osteomalacia due to impaired calcium and phosphorus homeostasis. However, its specific impact on tooth eruption and dental mineralization has only gained focused attention in recent years. Our findings corroborate recent studies that link low serum 25-hydroxyvitamin D with delayed dental eruption and enamel anomalies in children.

For example, Şahin and Toptancı (2024) reported a significant association between lower serum Vitamin D levels and delayed tooth eruption in a pediatric cohort, suggesting that deficient children are more likely to experience delayed eruption compared to their peers with normovitaminotic status. This aligns with our observation of over 50% delayed eruption in the Vitamin D-deficient subgroup. Similarly, systematic reviews by Ziada et al. (2025) and Mikołajczyk et al. (2025) emphasize the role of Vitamin D in dental tissue development, including amelogenesis and odontogenesis, which may influence eruption timing. These collective findings

reinforce the clinical significance of Vitamin D status in pediatric oral development.

Conversely, some studies exploring Vitamin D and dental caries (Li et al., 2023; International Dental Journal, 2024) focus primarily on enamel susceptibility to demineralization rather than eruption timing. Although caries and eruption patterns are related developmental outcomes, our study specifically isolates eruption timing as a distinct clinical endpoint, supporting the notion that Vitamin D's influence extends beyond preventive oral disease to fundamental developmental milestones.

Biological Mechanisms: The delayed eruption observed in Vitamin D-deficient children can be explained by the biochemical and molecular roles of Vitamin D in mineral metabolism. Active Vitamin D (1,25-dihydroxyvitamin D) regulates intestinal calcium and phosphorus absorption — essential minerals for bone and dental mineralization. Without sufficient Vitamin D, calcium absorption decreases, leading to secondary hyperparathyroidism, mobilization of calcium from bone, and altered mineral metabolism, which can impair alveolar bone formation and consequently delay tooth eruption.

Vitamin D also directly influences gene expression related to odontoblast and ameloblast differentiation. Experimental evidence highlights that Vitamin D regulates amelogenin and other enamel matrix proteins necessary for normal tooth formation. Insufficient Vitamin D during critical periods of odontogenesis could theoretically slow down dentoalveolar development, manifesting clinically as delayed eruption. These molecular pathways provide a plausible biological basis supporting our clinical observations.

Public Health and Clinical Implications: The high prevalence of Vitamin D deficiency in our study cohort (over 70% when deficiency and insufficiency are combined) reflects a broader global and regional public health concern. Studies from various geographic regions have documented widespread hypovitaminosis D among children due to limited sunlight exposure, dietary insufficiency, and lifestyle factors — a pattern mirrored in our population.

Delayed tooth eruption itself has practical implications for children's oral health and quality of life. Late eruption can lead to malocclusion, increased risk of impaction, orthodontic complications, and psychosocial concerns related to appearance or peer comparison. From a pediatric dentistry perspective, recognizing modifiable risk factors like Vitamin D status can help clinicians intervene early to optimize dental development outcomes.

Routine assessment of Vitamin D status during pediatric health evaluations may be beneficial, particularly in regions with high deficiency prevalence. Early supplementation, dietary counseling, and safe sun exposure practices could mitigate developmental delays in dentition and support overall skeletal health.

Limitations

While this study provides meaningful insights, several limitations should be acknowledged:

- **Cross-sectional Design:** Causality cannot be conclusively established. Longitudinal studies are needed to confirm temporal relationships between Vitamin D levels and eruption timing.
- **Confounding Factors:** Although we controlled for age and gender, other potential influences such as genetic determinants, socioeconomic status, nutritional intake, and endocrine factors (e.g., thyroid function) were not fully accounted for.
- **Single Measurement:** Vitamin D was measured at one point in time. Serial measurements would better characterize chronic deficiency and its impact over the eruption period.
- **Sample Size and Setting:** The study population was drawn from a single tertiary care center. Results may not be fully generalizable to broader demographic or ethnic groups without multicenter data.

Future studies addressing these limitations and exploring intervention outcomes (e.g., Vitamin D supplementation effects on eruption timing) are strongly recommended.

Future Directions: To further establish clinical recommendations, longitudinal cohort studies tracking Vitamin D status from early childhood through eruption milestones are warranted. Interventional trials evaluating whether Vitamin D supplementation

accelerates eruption or reduces eruption-related complications would provide robust evidence to guide preventive strategies.

Additionally, genetic studies exploring Vitamin D receptor polymorphisms and their interaction with dental development could enhance understanding of individual susceptibility to eruption delays.

Conclusion

The findings of the present study demonstrate a significant association between Vitamin D deficiency and delayed tooth eruption in children aged 6–12 years. Children with deficient serum 25-hydroxyvitamin D levels exhibited a markedly higher prevalence and risk of delayed eruption compared to those with sufficient Vitamin D status. These results underscore the important role of Vitamin D in normal dental development, likely mediated through its effects on calcium–phosphorus metabolism, alveolar bone growth, and odontogenesis.

Given the high burden of Vitamin D deficiency observed in the study population, delayed tooth eruption may serve as an early clinical indicator of underlying nutritional inadequacy. Early identification and correction of Vitamin D deficiency through dietary optimization, supplementation, and appropriate sun exposure could contribute to timely dental eruption and overall skeletal health in children.

From a clinical and public health perspective, integration of nutritional assessment—including Vitamin D status into routine pediatric and dental evaluations may help prevent developmental dental delays and their associated complications. Further longitudinal and interventional studies are warranted to establish causality and to evaluate the impact of Vitamin D supplementation on eruption timing and long-term oral health outcomes.

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 20. Reviews in pediatric oral health highlight the importance of mineral and hormone regulation on eruption timing.
 21. Emerging clinical evidence suggests early life Vitamin D exposure influences amelogenesis and mineralization relevant to eruption patterns.
 22. Cohort studies emphasize prenatal and early childhood Vitamin D effects on bone and dental outcomes.
 23. Recent interventional and cross-sectional child health studies include Vitamin D measurement as part of dental.