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Association of Hypocalcemia and Elevated Parathyroid Hormone with Delayed Tooth Eruption in Children. A Cross-Sectional Study from a Pediatric and Dental Cohort

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Abstract

Objectives: This study aimed to evaluate the association between biochemical parameters and stunted odontogenesis in children attending dental and pediatric clinics.

Study design and setting: This cross-sectional study was conducted at the dental OPD of LUMHS, Jamshoro, Sindh**.**

Methodology: After approval from the research ethics committee (DREC/113, dated 17/06/24), this study was conducted among 250 children aged 2–16 years, from 1st July 2024 to 31 December 2024. Clinical assessment included dentine scoring and evaluation of delayed tooth eruption. Biochemical analysis measured serum calcium, PTH, vitamin D, magnesium, sodium, potassium, iron, folic acid, calcitonin, urea, and creatinine. Comparative analysis, ANOVA, and regression were performed using SPSS, with significance set at $p < 0.05$.

Results: Delayed tooth eruption was observed in 88.4% of participants. Mean serum calcium was below normal (7.98 ± 1.10 mg/dL), with elevated mean PTH (18.90 ± 22.78 pg/mL). Children with delayed eruption had lower calcium levels ($p = 0.001$) and higher PTH levels ($p = 0.021$) than those without delay. Regression analysis revealed a positive linear relationship between PTH and serum calcium ($y = 7.38 + 0.03x$, $R^2 = 0.429$).

Conclusion: This study highlighted that disturbances in mineral metabolism, particularly hypocalcemia and compensatory PTH elevation, are associated with delayed tooth eruption and dentine defects.

Keywords: Dentine Score, Hypocalcemia, Parathyroid Hormone, Tooth Eruption,

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INTRODUCTION:

Tooth eruption is not simply about breaking teeth through the gums but is an exceptionally modified physiological process that relies on the harmonious relationships of hormones, mineral metabolism, and appropriate nutrition. The timing and sequence of tooth eruption are influenced by genetic, environmental, nutritional, and endocrine factors. Deviations from normal eruption patterns, particularly delayed tooth eruption, may serve as early indicators of underlying systemic or metabolic disorders and have been associated with functional, nutritional, and psychosocial consequences in children. Among them, the parathyroid hormone (PTH) played a critical role in maintaining the stable calcium level in the bloodstream, which is very important in the formation of healthy enamel and dentine during the development of teeth. PTH performs this by attracting calcium in the bones, as it enables the kidneys to retain calcium.

Studies have demonstrated that children who lack adequate calcium or vitamin D can have delayed tooth eruption, brittle enamel or dentin problems, which are symptoms of underlying nutritional or metabolic problems, especially in children who grow up. Calcium is a fundamental mineral

required for skeletal growth and dental mineralization. Adequate serum calcium levels are essential for the formation of enamel and dentin, as well as for the remodeling of alveolar bone that allows normal tooth eruption. Hypocalcemia during childhood has been linked to impaired bone mineralization, delayed skeletal maturation, and abnormalities in dental development. Endocrine regulation of calcium homeostasis is primarily mediated by parathyroid hormone (PTH), which increases in response to low serum calcium levels to maintain mineral balance. Chronic hypocalcemia often results in elevated PTH levels, a condition known as secondary hyperparathyroidism. Elevated PTH alters bone turnover by increasing osteoclastic activity, which may disrupt normal alveolar bone dynamics and interfere with the eruption pathway of teeth. While the skeletal effects of hypocalcemia and secondary hyperparathyroidism are well established, their specific impact on dental eruption has not been adequately investigated, particularly in pediatric populations.

Previous studies examining delayed tooth eruption have largely focused on local dental factors, genetic syndromes, or nutritional deficiencies, with limited attention to biochemical and hormonal contributors.4 The dental manifestations of calcium and PTH imbalance may therefore be under-recognized, leading to missed opportunities for early diagnosis of metabolic disorders. Understanding the association between serum calcium levels, PTH concentrations, and delayed tooth eruption could provide valuable insights for both pediatricians and dental practitioners.

Earlier literature has documented that the timing of tooth eruption can be influenced by systemic conditions that disturb normal growth and mineralization. Research in pediatric endocrinology has shown that inadequate calcium availability during early childhood interferes with dentine and enamel formation and may slow the eruptive process. Experimental and clinical studies have also demonstrated that sustained elevation of parathyroid hormone, often secondary to chronic hypocalcemia, alters bone turnover and the resorptive activity required for normal eruption of teeth. In addition, population-based studies have reported a higher frequency of delayed eruption among children with nutritional deficiencies, particularly in regions where vitamin D insufficiency is widespread. Despite these observations, many studies have assessed dental findings or biochemical abnormalities in isolation, leaving limited evidence on their combined effect.

These visible dental changes often indicate underlying nutritional or metabolic issues, particularly in growing children. It is also important to introduce complementary foods at the appropriate time, and the World Health Organization proposes starting at approximately six months. Postponing this step or leaving it too long with the help of exclusive breastfeeding may increase the probability of calcium and vitamin D deficiency. But the impact of various weaning methods and nutritional cultures on the biochemical indicators of children and on the formation of teeth has not been studied in South Asia, such as Pakistan.

To fill this gap, our study focused on children visiting the Dental Outpatient Department and Pediatric Ward at Liaquat University of Medical & Health Sciences (LUMHS). We set out to explore the relationship between serum calcium and PTH levels and delayed tooth eruption and dentine defects, and examine the influence of other nutrients and minerals, such as magnesium, sodium, potassium, iron, folic acid, vitamin D, and calcitonin, on dental health.

METHODOLOGY:

The data were collected as a cross-sectional analytical study at the Dental outpatient department (OPD) and pediatrics ward of Liaquat University of Medical and Health Sciences (LUMHS), Jamshoro, between 1st July 2024 and 31st December 2024. The purpose of the study was to examine the association between the biochemical parameters, such as serum calcium, parathyroid hormone (PTH), and other micronutrients, and odontogenesis stunting in children. There were 250 children aged 2-16 years who were visiting the dental OPD or pediatric clinics. The sampling criteria of children were non-probability consecutive sampling. The inclusion criteria included: Children with reported delayed tooth eruption or dentine defects, and who were available to have their blood sampled and parental consent. Exclusion criteria were: Children with known systemic illnesses that would impair calcium metabolism (e.g., chronic kidney disease, rickets because of genetic disorders). Past medical history of bone or tooth mineralization affecting drugs. The clinical examination involved Recording Age and gender, and nutritional status, which was measured by obtaining Body Mass Index (BMI) and Mid-Upper Arm Circumference (MUAC). Dental checkup conducted by trained pediatric dentists to check: Tooth eruption status (Delayed/Normal, according to standard eruption charts) and Dentine involvement measured on a scale of 0 (no defect) to 4 (severe defects). Biochemical Analysis Venous blood samples were taken and tested as follows: Serum calcium (mg/dL), Parathyroid hormone (PTH) (pg/mL), Serum magnesium, sodium, potassium, iron, folic acid, vitamin D, and calcitonin, Urea and creatinine to measure renal functioning. All tests were performed on the standard analysis using automated systems in the hospital lab. The data were typed and computed in the SPSS software (version 23.0). Participant demographics, biochemical parameters, dentine scores, and weaning practices were summarised through descriptive statistics (mean ± SD, frequencies, and percentages). Comparative studies were made by Independent t-tests to compare biochemical parameters in children with and without delayed eruption. ANOVA was used to test the differences in weaning. The dependence between PTH and serum calcium (as a regression equation and R2) was evaluated by

the use of correlation and regression analysis. The issue was established as $p < 0.05$.

RESULTS:

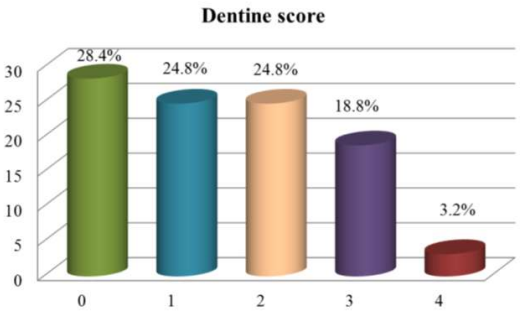
Table No. 01: The age of the children studied was 5 to 15 years, with the mean age of the children being 9.34 +- 3.45 years. The anthropometric evaluation showed an average body mass index (BMI) of 17.29 +- 2.78 /m2, and the mean Mid-Upper Arm Circumference (MUAC) was 14.89 +- 3.92 cm, and oddly enough, the growth patterns in terms of body mass index and Mid-Upper Arm Circumference are generally lean and quite typical of this age group. Biochemical examination showed a mean level of serum calcium was 6.89 +- 1.20 mg/dL below the normal range of pediatric level, and a mean of Parathyroid hormone (PTH) concentration was 10.89 +- 2.87 pg/mL. Mean levels of serum sodium and potassium were 135.00 +- 3.31 mmol/L and 3.23 +- 0.69 mmol/L, respectively, were almost at the lower end of the normal range and the mean level of magnesium was 1.65 +- 0.43 mg/dL. Renal markers of function indicated a mean urea level of 30.65 +- 12.05 mg/dl and a mean creatinine of 0.32 +- 0.12mg/dl, which were within normal pediatric limits. Also, the average serum level of iron was 133.80 +- 3.32mg/dl, folic acid was 3.43 +- 0.83 ng/mL, and vitamin D was very low at 1.89 +- 0.54 ng/mL

Graph No. 1 indicates that the dentine scores were between 0 and 4, and this represented the different levels of dentine involvement. The greatest percentage of the children (28.4) had a dentine score of 0, which implies that no evidence of dentine defects was detected. The scores of 1 and 2 were both standard, with 24.8 percent of children having each score, which are considered mild dentine changes in almost half of the sample. A dentine score of 3, which was more severe dentine changes, was found in 18.8 percent of the participants. The proportion of children with the most severe dentine involvement of 4 was the lowest at only 3.2% Graph No. 2: Study of the pattern of tooth eruption in the study participants showed that there was a significantly high percentage of delayed eruption. A total of 250 children were found to have delayed tooth eruption, with only 221 children (88.4%) having delayed eruption, with only 29 children (11.6) showing no delay. Graph No. 3: Study of the pattern of tooth eruption in the study participants showed that there was a significantly high percentage of delayed eruption. A total of 250 children were found to have delayed tooth eruption, with only 221 children (88.4%) having delayed eruption, with only 29 children (11.6) showing no delay. These results indicate that the delayed eruption of teeth was a significant clinical observation in the cohort of the study. The present high frequency can indicate that it is related to some underlying disturbances in mineral metabolism, nutritional deficiencies, or hormonal causes. Table No. 2, the comparative analysis of the biochemical parameters of children with and without delayed tooth eruption, indicated the significant difference in the main indicators of mineral metabolism. The mean serum calcium level (7.97 +- 0.50 mg/dL) of children with delayed eruption (n = 29) was found to be lower than that of those without delay (8.09 +- 1.16 mg/dL), and the difference between them was statistically significant ($p = 0.001$). Also, the mean parathyroid hormone (PTH) level (21.11 +- 24.35 pg/mL) was significantly higher in the delayed eruption group ($p = 0.021$), although it was also significantly higher in the non-delay group (9.11 +- 2.62 pg/mL). Though there was no significant difference between means of serum magnesium levels between groups ($p = 0.065$), children with delayed eruption were found to have higher mean serum iron levels (122.21 +- 10.91 ug/dL) than those with no delay (97.78 +- 31.76 ug/dL), which was significantly different ($p = 0.001$). The differences in the levels of folic acid and vitamin D did not make a significant difference between the two groups ($p = 0.674$ and $p = 0.563$, respectively).

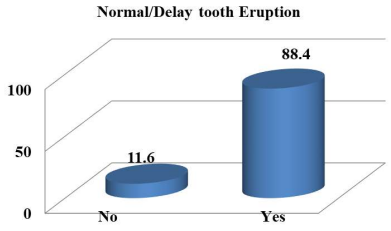
Table 01: Descriptive Analysis of Study Population

Variable	Mean ± SD
AGE	9.340 ± 3.45
BMI	17.29 ± 2.78
MUAC	14.89 ± 3.92
SERUM CALCIUM	6.89 ± 1.2
PARATHYROID HORMONE	10.89 ± 2.87
SODIUM	135.00 ± 3.31
POTASSIUM	3.23 ± 0.69
MAGNISUM	1.650 ± 0.43
UREA	30.65 ± 12.05
CREATNINE	0.32 ± 0.12
IRON	1.33.80 ± 3.32
FOLIC ACID	3.43 ± 0.83
VIATMIN D	1.89 ± 0.54

Graph 01: Dentine Score of the Participants



Graph 2: Delayed Tooth Eruption



Graph 3: Relationship between Parathyroid Hormone and Serum Calcium

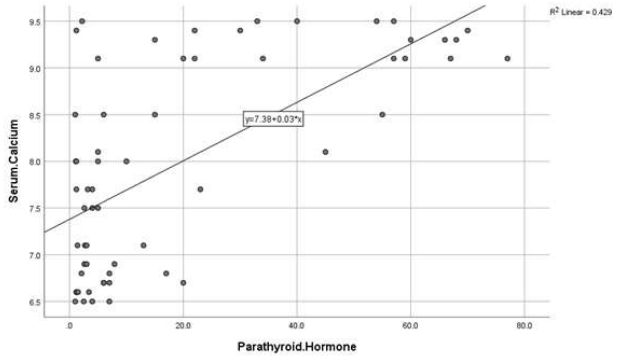


Table 2: Biochemical Variables and Delayed Tooth Eruption

Variables	Delay Eruption	N	Mean	Std.	p-value
Serum calcium	Yes	29	7.966	.5012	0.001
	No	221	8.086	1.1592	
Parathyroid hormone	Yes	29	21.106	24.3460	0.021
	No	221	9.106	2.6186	
Serum magnesium	Yes	29	1.745	.4306	0.065
	No	221	1.751	.3313	
Serum Iron	Yes	29	122.207	10.9067	0.001
	No	221	97.783	31.7632	
Folic acid	Yes	29	9.328	2.5112	0.674
	No	221	7.352	2.6772	
Vitamin D	Yes	29	37.655	3.4875	0.563
	No	221	35.801	4.0571	

DISCUSSION:

This study evaluated how mineral metabolism disruptions are linked to the retarded eruption of teeth among children between the ages of 5-15 years. The average serum calcium concentration of the participants (6.89 +- 1.20 mg/dL) was lower than the normal pediatric range. Conversely, the average parathyroid hormone (PTH) level (10.89 +- 2.87 pg/mL) was a sign of the body adjusting itself to calcium homeostasis by compensatory mechanisms. The results are in line with this latest research, which has reported that chronic hypocalcemia, frequently coupled with either subclinical or overt vitamin D deficiency, causes a considerable amount of alteration to odontogenesis and tooth eruption in children.

The average serum vitamin D content in the present study (1.89 -0.54 ngs/mL) was significantly low, and this is in line with the national and global data showing that a large proportion of children in South Asia. Vitamin D deficiency and this deficiency triggers PTH to be released and resultantly mineralization process, without which children cannot have their dentine and enamel erupt and form normally.

The anthropometric measurements of our cohort, such as BMI (17.29 +- 2.78kg/m2) and MUAC (14.89 +- 3.92 cm), reflected fairly lean and not severely malnourished patterns of growth. This implies that macronutrient levels are possibly okay, but there is a problem with the specific micronutrient deficiencies, especially calcium and vitamin D, which are potentially causing stunted odontogenesis. The rest of the biochemical parameters, sodium, potassium, magnesium, urea, and creatinine, were within normal ranges, which ruled out the possibility of any significant renal or systemic disease leading to a secondary effect on mineral metabolism.

These results highlight the role of early biochemical screening and specific nutritional interventions. The current research has been associated with the effectiveness of vitamin D and calcium supplementation in correcting the state of hypocalcemia and dental outcomes in children at risk. Public health policies that emphasize dietary education, regular pediatric screening, and fortified food programs can help decrease the rate of mineral metabolism disorders and associated effects on oral health.

The frequencies of dentine scores in this group of people give invaluable information about the clinical presentation of the disturbance of mineral metabolism and nutritional deficiencies in other groups of work. Although a dentine score of 0 (perfect dentine) is shown by 28.4% of the children, almost half of them had mild defects (scores 1 and 2, 24.8 and 24.8, respectively), and a considerable proportion of respondents had moderate (score 3, 18.8) and severe tooth defects (score 4, 3.2). This trend is generally in agreement with the other studies that have found a correlation between differences in the status of calcium and vitamin D and the degree of dentine and enamel hypomineralization.

The moderate to severe dentine defects seen in more than one-fifth of the children imply that alterations in mineral homeostasis, e.g. hypocalcemia and hypovitaminosis D recorded in the biochemical analysis, may have a direct effect on dentine matrix formation and mineralisation.4 and the relatively high prevalence of mild dentine changes might be due to chronic subclinical deficiencies or marginal hormone imbalances, e.g. high levels of parathyroid hormone (PTH) as seen in the study, and this would adverse .

These results highlight the complexity of the etiology of dentine defects, which concerns not only those at the systemic nutritional level, but also the local developmental processes. Their afterthought is the significance of screening and early intervention on the dietary habits because even slight or moderate changes in the dentine may predispose the children to caries, sensitivities, and long-term dental-related complications.

The fact that there was a significantly high proportion of delayed tooth eruption in this cohort, with 88.4% of the participants affected by the condition, brings to attention the importance of the possibility of systemic factors influencing the dental development of children. This is an

excessive frequency because the frequency normally reported in population-based studies is between 6 and 15 per cent, implying that kids who visit these dental outpatient and pediatric clinics are a very vulnerable population. This observation is consistent with the biochemical evidence of the study that proved that there was a high level of hypocalcemia, serious vitamin D deficiency, and high levels of parathyroid hormone (PTH). These interruptions may damage the activity of odontoblasts and mineralisation of enamel, slowing down eruption.

Besides, the risk has been suggested to be increased by the combined effect of chronic hypovitaminiosis D and secondary hyperparathyroidism, which has been reported to be the cause of delay in tooth eruption and dentofacial malformation in various children's studies.18 The nutritional contribution to the risk, due to the adequacy of nutrition in dental follicle formation and eruption pathway resorption, is further suggested by the borderline BMI, MUAC, and low folic acid levels of the sample. The nutritional contribution to the risk, due to the adequacy of nutrition in dental follicle formation and eruption pathway resorption, is further suggested by the borderline BMI, MUAC, and low folic acid levels of the sample.

Altogether, these results point to the conclusion that delayed eruption is not a local dental problem only, but it is likely to be a manifestation of systemic disturbances in mineral metabolism and nutrition. This highlights the significance of interdisciplinary screening, such as the use of biochemical measures, in the assessment of pediatric patients with a delay of eruption, in order to detect and treat possible reversible systemic factors.

The fact that the regression equation as $y = 7.38 + 0.03x$, has a coefficient of determination $(R2) = 0.429$, suggests that about 42.9 percent of the variation in the level of serum calcium can be explained by the difference in the level of parathyroid hormone among the study participants. This observation conforms to known physiological mechanisms where PTH is central in ensuring calcium homeostasis by enhancing bone resorption, renal calcium reabsorption, and the stimulation of vitamin D activation. The given trend, in which the increase in serum calcium was observed to be correlated with the increased levels of PTH, is indicative of a compensatory mechanism expected of secondary hyperparathyroidism, which is usually activated by chronic cases of hypocalcemia or vitamin D deficiency

The biochemical parameters comparison between children who experience delayed tooth eruption and those who do not gives additional support to the fact that mineral metabolism disruptions are the factors that contribute to the odontogenesis stunting. True to their name, children with delayed eruption showed a much lower average serum calcium level (7.97 +- 0.50 mg/dl) and much higher average parathyroid hormone (PTH) levels (21.11 +- 24.35 pg/ml), respectively, with p-values (0.001, 0.021) of 0.001 and 0.021. Such results are also aligned with the physiological process in which chronic hypocalcemia stimulates secondary hyperparathyroidism, whereby PTH release is augmented to reestablish calcium homeostasis. Although high levels of PTH may also stimulate bone resorption and alter the eruption cycles of dental follicle tissues, this may disrupt normal tooth development.

Interestingly, the mean levels of serum magnesium did not significantly differ, but the delayed eruption group had strongly elevated serum iron levels ($p = 0.001$). This is contrary to certain reports in which iron deficiency is associated with delayed eruption. This could be due to an increase in serum iron levels that could be related to dietary habits, supplementation, or inflammatory processes, but further research is needed to bring an understanding to this relationship.

The differences in the folic acid and vitamin D levels between groups were not statistically significant. Nevertheless, the overall average vitamin D content was significantly low in the cohort, in line with hypovitaminosis D as a background factor. The reported biochemical pattern supports the idea that a delay in eruption in the pediatric population is multifactorial, although reduced serum calcium and compensatory PTH raise seems to be the primary mechanisms that disrupt the eruption of teeth and mineralisation promptly.

The results highlight the clinical relevance of early biochemical evaluation in children with delayed eruption that allows specific interventions, including calcium and vitamin D supplementation, to bring the eruption on track and possibly enhance the dental outcomes.

The cross-sectional design limits causal inference between mineral imbalance and delayed tooth eruption. As the study was conducted at a single center using non-probability sampling, the findings may not be generalizable to the broader pediatric population. Dietary intake, sun exposure, socioeconomic status, and supplementation history were not assessed and may have acted as confounding factors. Biochemical parameters were measured at a single time point, which may not reflect long-term mineral status. In addition, dental eruption was assessed clinically without radiographic confirmation, which could have affected measurement precision.

CONCLUSION:

This cross-sectional study demonstrates that delayed tooth eruption in children is strongly associated with disturbances in mineral metabolism, particularly hypocalcemia accompanied by elevated parathyroid hormone levels. The high prevalence of delayed eruption observed in this cohort underscores that dental developmental delay is not merely a local oral finding but often reflects underlying systemic and biochemical imbalance. The consistent finding of low serum calcium with compensatory PTH elevation supports

the role of secondary hyperparathyroidism in altering normal odontogenesis and eruption pathways.

Although severe hypovitaminosis D was common across the study population, its lack of significant difference between children with and without delayed eruption suggests that calcium–PTH dynamics play a more direct role in eruption timing than vitamin D status alone in this setting. The presence of mild to severe dentine defects in a substantial proportion of participants further reinforces the impact of chronic mineral imbalance on dentine formation and mineralization.

Taken together, these findings highlight the importance of integrating biochemical evaluation into the assessment of children presenting with delayed tooth eruption. Early identification of hypocalcemia and related hormonal changes may allow timely nutritional and medical interventions, potentially improving dental development and broader skeletal outcomes. Interdisciplinary collaboration between pediatricians and dental practitioners is essential to address these reversible systemic factors and to reduce long-term oral health complications in vulnerable pediatric populations.

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Shakil Ahmed Shaikh: Critical Analysis, final approval
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Kalsoom Jawed: Data Analysis
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Hira Saeed Khan: Write up, data analysis

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