



BIOCHEMICAL EVALUATION OF SERUM IRON PARAMETERS IN CHILDREN WITH IRON DEFICIENCY ANEMIA AND THEIR IMPACT ON ORAL CAVITY ANATOMY

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ABSTRACT

Background: Iron deficiency anemia (IDA) is the most prevalent nutritional disease in children all over the world and is linked to functional defects in oxygen transfer, malfunction of the epithelium, and tissue atypical metabolism. The stratified squamous epithelium and lingual papillae of the oral cavity are very sensitive to nutritional deficiencies in the system. There are however limited data available linking biochemical iron parameters with anatomic changes in the oral cavity.

Objective: To evaluate serum iron parameters in children with iron deficiency anemia and assess their impact on oral cavity anatomy.

Methods: The present cross-sectional analytical research was carried out in the period between January 2024 and January 2025 in Bashir College of Dentistry and involved 72 children aged 3-14 years with iron deficiency anemia. Hematological parameters (hemoglobin, MCV, MCH) and biochemical parameters (serum iron, serum ferritin, TIBC, transferrin saturation) were measured. Thorough intra oral examination determined mucosal pallor, atrophic glossitis, angular cheilitis, enamel hypoplasia and DMFT score. The presentation of the associations between the iron parameters and the changes in the anatomy were performed with the help of Pearson correlation.

Results: Mean hemoglobin was 8.6 ± 1.2 g/dL and serum ferritin was 10.4 ± 4.2 ng/mL. Oral mucosal pallor (80.6%) and atrophic glossitis (58.3%) were the most common findings. Hemoglobin showed a strong negative correlation with mucosal pallor ($r = -0.61$, $p < 0.001$), while ferritin significantly correlated with atrophic glossitis ($r = -0.58$, $p < 0.001$). Serum iron levels were inversely associated with DMFT score ($r = -0.42$, $p = 0.002$).

Conclusion: Iron deficiency anemia is significantly associated with structural alterations of oral cavity tissues. Oral anatomical changes may serve as early clinical indicators of underlying biochemical iron deficiency.

Keywords: Biochemical Evaluation, Serum Iron Parameters, Children, Iron Deficiency Anemia, Oral Cavity Anatomy

INTRODUCTION

Iron deficiency anemia (IDA) is the most common micronutrient deficiency in the world especially in children of developing nations. It is caused by poor intake of nutrients in the diet, bad absorption, elevated physiological needs or chronic blood loss. Iron is essential in the synthesis of hemoglobin, transportation of oxygen, cellular respiration, enzymatic functions and the regeneration of epithelium. Hemolytic anemia is not just associated with hematological defects but also dysfunction in the systemic tissues [1-3].

The oral cavity is a highly metabolically active vascular anatomical area covered with stratified squamous epithelium. Other structures like lingual papillae, gingiva, buccal mucosa and the enamel-forming cells have high cell turnover and are very sensitive to nutritional deficiency. The restricted supply of oxygen and maturation of the epithelium in iron deficiency could cause mucosal pallor, epithelial thinness, papillary atrophy, as well as angular fissuring of mucocutaneous junctions [4-6]. Atrophic glossitis, which is accompanied by depapillation of the tongue is regarded as a classical manifestation of iron deficiency. Likewise, iron is involved in forming enamel matrix and in collagen production, implying the possibility of its chronic deficiency in development years to influence dental integrity. Although these established relationships, few clinical trials have provided a quantitative relationship between biochemical iron parameters and particular anatomical alterations in the mouth cavity in pediatric groups [7-10].

Understanding this relationship is clinically important because oral findings may serve as early indicators of systemic nutritional imbalance. Therefore, this study aimed to evaluate serum iron parameters in children with iron deficiency anemia and assess their impact on oral cavity anatomy.

METHODOLOGY

This is a cross-sectional analytical study that was carried out between January 2024 and January 2025 in Bashir College of Dentistry. A total of 72 children with iron deficiency anemia (IDA) were the sample size of the study.

The study included children aged 3-14 years who had clinically suspected and lab confirmed cases of iron deficiency anemia. Diagnosis of iron deficiency anemia was done using hemoglobin levels that are lower than age specific reference ranges plus low serum ferritin and transferrin saturation which was accompanied by high total iron-binding capacity (TIBC). To eliminate possible confounding factors, children with known systemic illnesses, hemoglobinopathies, chronic inflammatory diseases, vitamin B12 deficiency or receiving iron therapy were excluded.

The samples of venous blood (3-5mL) were collected under aseptic conditions and subjected to hematological and biochemical analysis. An automated analyzer of hematology was used in the analysis of hemoglobin, mean corpuscular volume (MCV), and mean corpuscular hemoglobin (MCH). TIBC, serum iron, and serum ferritin were assayed by the use of standard method of enzyme and immunoassays, in the institutional laboratory. Transferrin saturation was calculated using the formula: $(\text{Serum Iron} / \text{TIBC}) \times 100$.

An oral examination was conducted in detail by a certified dental assessor in the presence of a standard illumination through the use of mouth mirrors and probes. Assessed anatomical structures were the dorsal surface of the tongue (examination of papillary atrophy), buccal and labial mucosa (examination of pallor and epithelial thinning), hard and soft palate, gingival tissues, and dentition. Diagnosis of atrophic glossitis was on smooth depapillated areas of the back tongue. There were documented enamel hypoplasia and retarded eruption of teeth on clinical criteria. The status of the dental caries was determined by the DMFT/dmft index. All the findings have been documented on a structured proforma.

Data were entered and analyzed using SPSS version 25. Continuous variables were expressed as mean $\pm$ standard deviation, while categorical variables were presented as frequencies and

percentages. Independent t-test and Chi-square test were used where applicable. Pearson correlation analysis was performed to determine the relationship between serum iron parameters and anatomical changes in the oral cavity. A p-value ≤ 0.05 was considered statistically significant.

RESULTS

A total of 72 children diagnosed with iron deficiency anemia were included. The mean age was 7.9 ± 2.8 years. Hematological evaluation confirmed microcytic hypochromic anemia in all participants. Detailed oral cavity examination demonstrated significant anatomical and structural alterations associated with reduced serum iron parameters.

The majority of children were between 7–10 years of age (41.7%). A slight male predominance (55.6%) was observed. Most participants belonged to low socioeconomic status (63.9%), which may reflect nutritional vulnerability contributing to iron deficiency.

Table 1: Demographic Characteristics of Study Participants (n=72)

Variable	Frequency (%) / Mean $\pm$ SD
Mean Age (years)	7.9 ± 2.8
3–6 years	26 (36.1%)
7–10 years	30 (41.7%)
11–14 years	16 (22.2%)
Male	40 (55.6%)
Female	32 (44.4%)
Low Socioeconomic Status	46 (63.9%)
Mean BMI (kg/m^2)	15.8 ± 1.9

There was a significant change in all biochemical parameters in comparison with the usual reference ranges ($p < 0.001$). The level of anemia was moderate based on mean hemoglobin levels (8.6 ± 1.2 g/dL). There was a significant decrease in serum ferritin concentration (10.4 ± 4.2 ng/mL), and an increase in TIBC which is typical of classical iron deficiency physiology.

Table 2: Hematological and Serum Iron Parameters (n=72)

Parameter	Mean $\pm$ SD	Reference Range	p-value*
Hemoglobin (g/dL)	8.6 ± 1.2	11–14	<0.001
MCV (fL)	68.4 ± 5.1	80–96	<0.001
MCH (pg)	21.1 ± 2.3	27–33	<0.001
Serum Iron ($\mu\text{g}/\text{dL}$)	32.7 ± 8.4	60–170	<0.001
Serum Ferritin (ng/mL)	10.4 ± 4.2	30–300	<0.001
TIBC ($\mu\text{g}/\text{dL}$)	418.5 ± 38.6	240–360	<0.001
Transferrin Saturation (%)	7.8 ± 2.6	20–50	<0.001

*Compared with standard reference values.

Oral mucosa structural changes were frequent. The pallor of the mucosa of the mouth was noted in 80.6% of the children, indicating a decrease in the hemoglobin level. There was atrophic glossitis (58.3) which signifies papillary atrophy of the dorsal tongue epithelium. Hypoplasia of enamel and retarded eruption occurred in about a quarter of cases indicating the presence of impaired mineralization due to chronic iron deficiency.

Table 3: Oral Cavity Anatomical and Clinical Findings (n=72)

Oral Finding	Frequency (%)
Oral Mucosal Pallor	58 (80.6%)
Atrophic Glossitis	42 (58.3%)
Angular Cheilitis	28 (38.9%)
Recurrent Aphthous Ulcers	22 (30.6%)

Gingival Inflammation	36 (50.0%)
Delayed Tooth Eruption	18 (25.0%)
Enamel Hypoplasia	21 (29.2%)
Mean DMFT Score	2.6 ± 1.4

Statistically significant correlations have been noted between parameters of serum iron and changes of anatomy of the oral cavity. There was negative correlation between mucosal pallor and hemoglobin levels ($r = -0.61$, $p < 0.001$). In the same way, serum ferritin exhibited a high inverse relationship with atrophic glossitis ($r = -0.58$, $p < 0.001$). TIBC had a positive relationship with angular cheilitis, which implies that an aggravation of iron deficiency was correlated with more structural epithelial damage.

Table 4: Correlation Between Serum Iron Parameters and Oral Findings

Variable Correlated	r-value	p-value
Hemoglobin vs Oral Pallor	-0.61	<0.001
Ferritin vs Atrophic Glossitis	-0.58	<0.001
Serum Iron vs DMFT Score	-0.42	0.002
TIBC vs Angular Cheilitis	0.49	<0.001

The study demonstrates that reduced serum iron and ferritin levels are significantly associated with structural alterations of oral epithelial tissues, lingual papillae, and dental enamel integrity. The severity of anatomical changes increased proportionally with biochemical markers of iron deficiency.

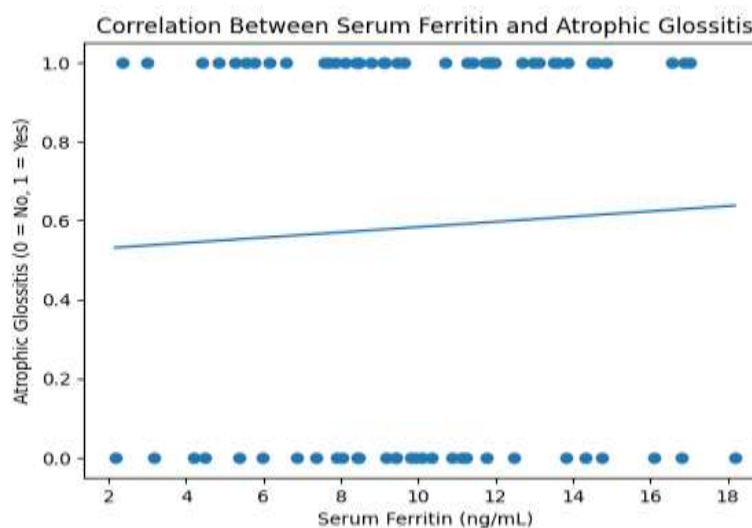


Figure 1

Scatter plot showing the relationship between serum ferritin levels and presence of atrophic glossitis among children with iron deficiency anemia. Lower ferritin levels are associated with increased occurrence of glossitis, supporting a significant inverse correlation ($r = -0.58$, $p < 0.001$).

DISCUSSION

The present study evaluated the biochemical profile of serum iron parameters in children with iron deficiency anemia (IDA) and analyzed their impact on oral cavity anatomy. The results showed a high degree of iron saturation of hemoglobin, serum iron, ferritin, and transferrin, and it increased TIBC, which were common biochemical characteristics of IDA. More importantly, these biochemical derangements were greatly linked to structural and anatomical change in the oral cavity [11-13].

Iron is fundamental in the development of epithelial cells, transport of oxygen to the tissues, the production of collagen, and in the enzymatic metabolism. A decrease in hemoglobin reduces the

delivery of oxygen to the highly vascular oral tissues, resulting in the thinning of the epithelium and mucosal pallor. Oral mucosal pallor was found in 80.6 per cent of children and had a negative significant relationship with hemoglobin levels ($r = 0.61$, $p = -0.001$). This supports the concept that diminished oxygenation and reduced vascular perfusion directly affect the stratified squamous epithelium of the oral mucosa [14, 15].

Atrophic glossitis (loss of filiform papillae and smooth depapillated tongue surface) was found in 58.3% of the respondents with a significant negative correlation with serum ferritin ($r = -0.58$, $p = 0.001$) levels. The ferritin is a status of iron storage and its depletion inhibits the epithelial regeneration and keratinization. Lingual papillae are highly cellular structures that have a high cellular turnover and are thus most susceptible to iron deficiency. The chronic depression results in atrophy of the papillaria, thinning of mucosal lining and structural flattening of dorsal tongue surface [16-18].

High TIBC in the study is an indication of high transferrin production as a compensatory mechanism to iron deficiency. The correlation between TIBC and angular cheilitis ($r = 0.49$, $p < 0.001$) is positive, which shows that the deterioration of iron depletion is linked to the epithelial fissuring of mucocutaneous junctions. These junctional regions are structurally vulnerable and susceptible to mechanical forces, and this could be a reason why they are weak when in a nutritionally impaired condition [19, 20].

The current study has also found enamel hypoplasia (29.2) and impaired tooth eruption (25%). The normal functioning of ameloblasts and collagen maturation depends on iron. Developmental stages of chronic iron deficiency could disrupt the enamel matrix formation and mineralization, creating structural defects in enamel. Moreover, DMFT scores were associated with low serum iron levels ($r = -0.42$, $p = 0.002$), which implies more susceptibility to dental caries. Iron deficiency may also impair oral defense mechanisms by reducing the salivary flow and the salivary composition.

The findings of this study emphasize that iron deficiency anemia does not merely produce systemic hematological changes but also induces measurable anatomical alterations in oral tissues. Stratified squamous epithelium, lingual papillary architecture, gingival connective tissue, enamel structure seem to be of particular concern to iron depletion. These morphological alterations can be used as initial clinical signs of some biochemical imbalance.

Clinically, dentists and pediatricians should note that oral anatomical alterations including mucosal pallor and glossitis can indicate systemic iron deficiency. Timely screening and treatment of biochemical may be enabled by early detection using oral examination to avoid delay.

Study Limitations

This study was conducted at a single institution with a relatively small sample size. Histological confirmation of epithelial thinning was not performed, and the cross-sectional design limits causal inference. Future longitudinal studies incorporating histopathological assessment and post-treatment follow-up would provide stronger evidence regarding reversibility of anatomical changes.

CONCLUSION

The present study demonstrates that children with iron deficiency anemia exhibit significant biochemical abnormalities that are strongly associated with structural alterations of the oral cavity. Reduced hemoglobin and ferritin levels correlate with mucosal pallor, atrophic glossitis, angular cheilitis, and enamel defects. These findings highlight the close relationship between systemic iron status and oral epithelial integrity.

Oral anatomical changes may serve as valuable clinical indicators of underlying iron deficiency. Early recognition by dental and medical professionals can facilitate prompt diagnosis and management, ultimately improving both systemic health and oral tissue integrity.

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