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Iron Deficiency Anemia as A Risk Factor for Dental Pulp Diseases: An Integrative Review

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Article Review

ABSTRACT

Iron deficiency anemia is characterized by reduced blood capacity to transport oxygen due to insufficient iron, an essential component of hemoglobin. This condition can have various implications for oral health, including dental pulp health. The human body must balance physiological, nutritional, and environmental factors to maintain optimal functioning. Iron salts react with gingival crevicular fluid and subgingival bacterial metabolites, staining teeth. Iron supplements typically have a highly acidic pH compromising dental enamel microhardness and increasing the risk of cavities. However, the severity of the damage varies depending on supplement acidity, frequency, duration, and method of administration. This article aims to conduct a comprehensive literature search to investigate the association between iron deficiency anemia and oral health issues with pulp pathology aspects as the focus of the study. To sustain an integrative literature review, articles published in English from the databases PubMed, Wiley Library, Science Direct and Scholar Google were examined. Iron deficiency anemia is a contributing factor to the higher incidence of post-endodontic pain. Some studies indicate other results suggesting that iron has a cariostatic effect on dental decay.

Keywords: Endodontics, Iron Deficiency Anemia, Oral Health.

La Anemia Ferropénica Como Factor de Riesgo de Enfermedades de la Pulpa Dental: una Revisión Integradora

RESUMEN

La anemia ferropénica se caracteriza por una capacidad reducida de la sangre para transportar oxígeno debido a la insuficiencia de hierro, un componente esencial de la hemoglobina. Esta condición puede tener varias implicaciones para la salud bucal, incluida la salud de la pulpa dental. El cuerpo humano debe equilibrar los factores fisiológicos, nutricionales y ambientales para mantener un funcionamiento óptimo. Las sales de hierro reaccionan con el líquido crevicular gingival y los metabolitos bacterianos subgingivales, tiñendo los dientes. Los suplementos de hierro suelen tener un pH altamente ácido que compromete la microdureza del esmalte dental y aumenta el riesgo de caries. Sin embargo, la gravedad del daño varía según la acidez del suplemento, la frecuencia, la duración y el método de administración. Este artículo tiene como objetivo realizar una búsqueda bibliográfica exhaustiva para investigar la asociación entre la anemia ferropénica y los problemas de salud bucal con los aspectos de patología pulpar como foco del estudio. Para sustentar una revisión bibliográfica integradora, se examinaron artículos publicados en inglés de las bases de datos PubMed, Wiley Library, Science Direct y Scholar Google. La anemia ferropénica es un factor que contribuye a la mayor incidencia de dolor posendodóncico. Algunos estudios indican otros resultados que sugieren que el hierro tiene un efecto cariostático sobre la caries dental.

Palabras clave: Endodoncia, Anemia Ferropénica, Salud Bucal.

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INTRODUCTION

Iron deficiency anemia (IDA) is characterized by reduced blood capacity to transport oxygen due to insufficient iron, an essential component of hemoglobin. This condition can have various implications for oral health, including dental pulp health. The human body must balance physiological, nutritional, and environmental factors to maintain optimal functioning (Leon-Rodriguez *et al*., 2024).

IDA is the most prevalent and treatable form of anemia worldwide (Elstrott *et al*., 2020). The clinical management of patients with IDA requires a comprehensive understanding of the many etiologies that can lead to iron deficiency including pregnancy, blood loss, renal disease, heavy menstrual bleeding, inflammatory bowel disease, bariatric surgery, or infrequent genetic disorders (Elstrott *et al*., 2020).

Iron is part of the subfamily of transition elements and is one of the most abundant metals on Earth, as well as an essential nutrient. It is a component of several metalloproteins and plays a vital function in essential biochemical activities, such as oxygen sensing and transport, electron transfer, and catalysis (Oliveira; Rocha; Fernandes, 2014).

Iron (Fe) is essential in various important functions, including oxygen transport, deoxyribonucleic acid synthesis, metabolic energy, and cellular respiration (Cappellini *et al*., 2022). Although necessary for cellular life, excess iron can generate reactive oxygen species, which cause oxidative stress, lipid peroxidation, and deoxyribonucleic acid damage, compromising cell viability and promoting cell death (Cappellini *et al.*, 2022).

An imbalance due to iron deficiency leads to anemia, which has adverse consequences that negatively impact the body (Leon-Rodriguez *et al*., 2024). Iron deficiency often leads to the prescription of ferrous sulfate as the primary treatment (Leon-Rodriguez *et al*., 2024).

Iron salts react with gingival crevicular fluid and subgingival bacterial metabolites, staining teeth. Iron supplements typically have a highly acidic pH compromising dental enamel microhardness and increasing the risk of cavities. However, the severity of the damage varies depending on supplement acidity, frequency, duration, and method of administration (Leon-Rodriguez *et al*., 2024).

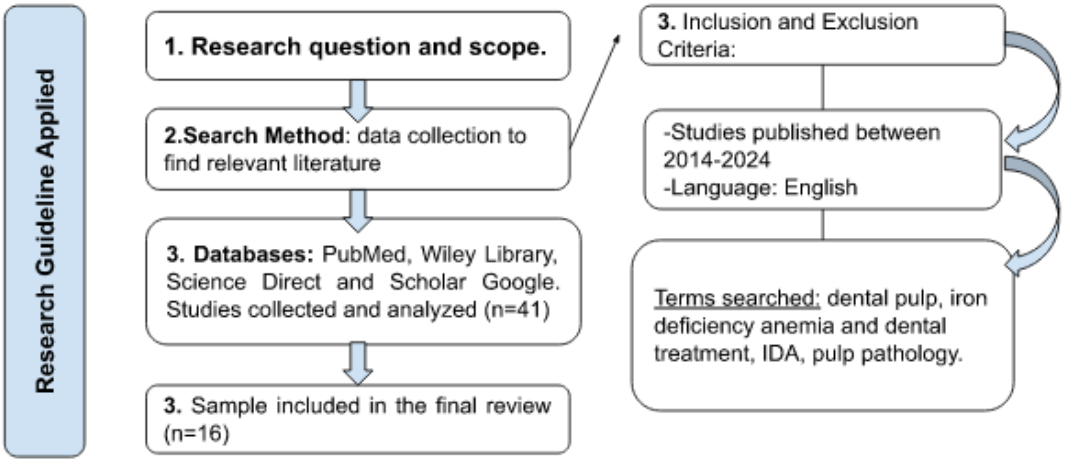
This article aims to conduct a comprehensive literature search to investigate the association between iron deficiency anemia (IDA) and oral health issues with pulp pathology aspects as the focus of the study.

METHODOLOGY

Building your research on and relating it to existing knowledge is the structure block of all academic research activities, regardless of discipline. The intent of using an integrative review method is to overview the facts base, to critically review and potentially reconceptualize and to expand on the theoretical foundation of the precise topic as it evolves. A literature review can be defined as a systematic method of collecting and synthesizing previous research (Jesus *et al*., 2024).

To sustain an integrative literature review, (N= 41) articles published in English from the databases (PubMed, Wiley Library, Science Direct and Scholar Google) were examined. After the review, only 13 articles published between 2014-2024 were included. The strategy to acquire the final study followed the steps described in **flowchart 1**, as shown:

Flowchart 1. Description of the methodology applied.



Source: elaborated by the authors (2024).

RESULTS AND DISCUSSION

Muckenthaler *et al.*, (2017) and Amrollahi & Tarrahi (2022), declare that Iron deficiency is the most common cause of anemia and represents a global health problem.

Iron-deficiency anemia is defined by low numbers of small (microcytic) and hypoferremic erythrocytes. In addition to erythropoiesis, iron is essential for mitochondrial function, DNA synthesis and repair, and many enzymatic reactions required for cell survival.

Auerbach and Adamson (2015) explain that iron deficiency (ID) causes decrements in energy, activity, quality of life, cognitive function, sexual function, and work productivity. Iron deficiency anemia is the most common hematological disorder and is a consequence of chronic blood loss or lack of iron consumption in diet (Kazemipoor *et al.*, 2022)

Signs of ID include pallor (with anemia), decreased papillation of the tongue, cheilosis (cracking at the corners of the mouth and prominent defects in the nail beds, including Mees lines and koilonychia, spooning of the nails. As these signs and symptoms are nonspecific and often are not present, the initial suspicion of ID usually comes from the laboratory, with microcytic or normocytic anemia triggering a more definitive workup (Auerbach and Adamson, 2015).

The laboratory diagnosis includes several tests, each requiring some degree of interpretation to be accurately applied. When asked to evaluate a patient for suspected ID, the doctors request the tests. Once the diagnosis of ID is made, several treatment options exist (Auerbach and Adamson, 2015).

Iron deficiency represents the most prevalent nutritional deficit on a global scale. Iron deficiency anemia is a global public health problem that affects developed and undeveloped countries, with important consequences on individual health, quality of life, and society with health, social, and economic repercussions.

Despite being present at all stages of life, the prevalence is high among certain vulnerable groups, such as children <5 years of age, women of childbearing age, and particularly pregnant women (Cappellini *et al*., 2022; Kazemipoor *et al.*, 2022).

4.1. EPIDEMIOLOGY

Anemia is a predominant problem worldwide, mainly affecting the pediatric population (Leon-Rodriguez *et al*., 2024). According to Kaundal *et al.,* (2020), Recent studies in iron-depleted women have challenged the current approach of treating iron-

deficiency anemia (IDA) with oral iron in divided daily doses.

The common causes of anemia are (1) iron deficiency anemia; (2) anemia of acute blood loss; (3) anemia of chronic inflammation; (4) anemia of malnutrition; and (5) inherited hemoglobinopathy. Iron deficiency anemia is the most common cause of anemia (11). Numerous factors such as genetic and dietary factors, inflammatory processes, and environmental factors like dental caries and low socioeconomic status are involved in iron deficiency anemia (Amrollahi; Tarrahi, 2022). According to the World Health Organization (WHO), IDA is confirmed if at least two out of three parameters (MCV, serum ferritin, and Hb) are lower than normal (Amrollahi; Tarrahi, 2022).

According to the Peruvian Ministry of Development and Social Inclusion, 42.9% of children aged six to 35 months suffer from anemia in the central Peruvian jungle (Leon-Rodriguez *et al.*, 2024). Shuaiqi et al., (2022) establish that early childhood caries remains one of the most common childhood diseases. Besides, iron deficiency anemia (IDA), which is a severe stage of iron deficiency (ID), is highly prevalent in preschool children (<5 years old).

Iron deficiency anemia has been reported high in the female population in Iran (52.3%) (Auerbach and Adamson 2015). Also, the prevalence of this disease is much higher in women than in men (Kazemipoor et al., 2022). The World Health Organization (WHO), in 1992, estimated that 37% of all women were iron deficient (Auerbach and Adamson 2015).

In a recent analysis of the global anemia burden, largely unchanged 13 years after the WHO report, Kassebaum et al., estimated that over 30% of the world's population is anemic, the majority being due to iron deficiency (Auerbach and Adamson 2015).

Iron deficiency (ID) is the most prevalent nutritional deficiency worldwide, accounting for approximately 50% of all cases of anemia (Velliyagounder; Chavan; Markowitz 2024). IDA is a pervasive health concern, affecting a staggering two billion individuals globally, with a significant majority residing in non-industrialized countries.

The prevalence of IDA exhibits variations across races, genders, and age groups, thereby presenting a complex epidemiological picture (Velliyagounder; Chavan; Markowitz 2024). In the United States, statistics reveal notable disparities in IDA rates. Among adults, approximately 2% of men, up to 12% of white women, and around 20%

of black women grapple with this condition (Velliyagounder; Chavan; Markowitz 2024).

Alarming trends emerge in pediatric populations as well, where 9% of children aged 12–36 months experience ID, and 33% of them are at risk of developing anemia. Likewise, iron deficiency anemia was more prevalent in children with dental caries (Amrollahi; Tarrahi, 2022) and WHO (World Health Organization) considers iron deficiency as the most common form of micronutrient malnutrition globally (Easwaran *et al.*, 2022).

4.2. IRON DEFICIENCY ANEMIA (IAD) AND PULP DISEASES

According to the classification system developed by the American Association of Endodontics, diagnosing pulpal and periapical diseases should be based on clinical and radiographic findings. The diagnosis of reversible pulpitis is based on objective criteria and subjective tests, reducing inflammation and restoring normal pulp function after appropriate treatment (Leon-Rodriguez *et al*., 2024).

Data has shown that IDA is intrinsically related to early childhood caries. Mechanistically, salivary gland functions are impaired in IDA, resulting in reduced salivary secretion and poor buffering capacity, which lead to inefficient wash-out dental plaque and food debris, thus triggering dental caries. In addition, there's a reduction of ferric ions in saliva and blood during IDA (Bansal *et al.*, 2016; Shuaiqi *et al.*, 2022).

One hypothesis by Abed *et al*., (2014) is that the low hemoglobin levels often observed in children with caries may be attributed to the body's inflammatory response, which may accompany rampant forms of dental caries (especially those involving pulpitis or abscesses) as this inflammation may trigger events that ultimately lead to the production of cytokines, which may, in turn, inhibit erythropoiesis and thus reduce the level of hemoglobin in the blood (Abed *et al*., 2014).

Since iron has anti-caries features, it inhibits the activity of S. *mutans* virulence factors and creates a caries-prone environment. Dental caries result from interactions between bacteria, such as S. *mutans*, saliva components, and dietary carbohydrates, forming a biofilm that closely adheres to the teeth' surfaces (Shuaiqi *et al*., 2022).

Previous cross-sectional studies have shown that children with anemia or IDA had a higher risk of caries than those without the deficiency (Abed *et al.,* 2014; Bansal

et al., 2016; Shuaiqi *et al*., 2022).

As well as developed by Schroth *et al.*, (2013), the association between caries and iron deficiency anemia occurs and children with early caries diseases appear to be at significantly greater odds of having low ferritin status compared with caries-free children and also seem to have significantly lower hemoglobin levels than the caries-free control group. Children with S-ECC also appear to be at significantly greater odds for iron deficiency anemia than cavity-free children (Schroth *et al.*, 2013; Bansal et al., 2016).

Iron deficiency reduces the buffering capacity of saliva, depriving it of its ability to counteract pH changes and protect oral tissues against acids from food or dental plaque. Therefore, it increases cariogenic potential. The progression of carious lesions facilitates bacterial invasion toward the dental pulp (Leon-Rodriguez et al., 2024).

The oral cavity is composed of both soft and hard structures, including teeth, which consist of enamel, dentin, and pulp, tissues that contain iron. Affecting these structures can initiate dysbiosis that leads to dental caries and if untreated, it can evolve into pulp inflammation (Leon-Rodriguez et al., 2024).

The pulp exposure to pathogens triggers a localized inflammatory response that releases inflammatory mediators. This process shows pulp pressure increase, resulting in acute pain in patients, a characteristic symptom of pulpal disease (Leon-Rodriguez et al., 2024).

A study developed by Leon-Rodriguez et al., (2024) clarifies that anemia configures a risk factor for pulpal disease as 82% of pulp disease patients suffer from it (Leon-Rodriguez et al., 2024).

Additionally, Acharya et al. observed that untreated dental caries may have systemic health effects. One hypothesis related to children with S-ECC is that they tend to have low Hb levels, which may be attributed to the inflammatory response accompanying severe dental caries, especially cases involving pulpitis or abscesses (Velliyagounder; Chavan; Markowitz 2024).

This inflammation triggers the production of cytokines, which may inhibit erythropoiesis and reduce Hb levels. Moreover, children with dental pain from S-ECC may have altered eating habits, and a highly cariogenic diet may lack nutritional value, potentially leading to poor growth (Velliyagounder; Chavan; Markowitz 2024). Poor

sleep quality due to dental pain may also contribute to a decreased production of glucocorticoids, further affecting growth. These observations highlight the potential systemic impact of untreated dental caries (Velliyagounder; Chavan; Markowitz 2024).

Iron deficiency anemia is a contributing factor to the higher incidence of post-endodontic pain in women (Kazemipoor et al., 2022). Up to the present, there is no study on the relationship between iron deficiency anemia and the response to pulpal sensibility tests. Based on the results of the present study, anemic women in comparison to healthy ones showed a lower threshold in response to the EPT test (Kazemipoor *et al.*, 2022).

Iron deficiency has been reported many times as causing discoloration of deciduous teeth and parents consider this issue as the beginning of caries in teeth due to taking iron drops (Asgari; Soltan; Sadeghi, 2020).

Patients with iron deficiency anemia may report symptoms such as fatigue, paleness and increased susceptibility to infections, which can also manifest in oral problems such as gum inflammation and a higher incidence of cavities, which can progress to affect the dental pulp (Kazemipoor *et al.*, 2022).

Therefore, iron deficiency anemia can negatively influence pulp health by compromising oxygenation, immunological response and the repair capacity of pulp tissues. Patients with iron deficiency anemia often present symptoms such as fatigue and paleness, which can reflect oral problems such as gum inflammation and a higher incidence of cavities, which can progress to affect the dental pulp (Kazemipoor *et al.*, 2022).

FINAL CONSIDERATIONS

Iron deficiency anemia can negatively influence pulp health through mechanisms such as reduced tissue oxygenation, impaired immune response, changes in microvasculature, and decreased tissue regeneration capacity. These factors make the dental pulp more vulnerable to diseases and infections, highlighting the importance of maintaining adequate iron levels for oral health.

Some studies indicate other results suggesting that iron has a cariostatic effect on dental decay. The cariostatic effects of iron have been attributed to various factors,

including the reduction of *Streptococcus Mutans* biofilm or inhibition of the bacterial enzyme glucosyltransferase by this metal ion.

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