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Convergence between anemia and dental pulp diseases: an in-depth analysis

Convergência entre a anemia e as doenças da polpa dentária: uma análise aprofundada

Convergencia entre anemia y enfermedades de la pulpa dental: un análisis en profundidad

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ABSTRACT

Anemia is a significant health concern worldwide due to a shortage of red blood cells or hemoglobin. An imbalance due to iron deficiency leads to anemia, which has adverse consequences that negatively impact the body and oral health. Pulp pathology is the generic term used in the description of pulp diseases as a morphofunctional ensemble. The clinical diagnosis relies on the correlation of information regarding the inflammatory state of dental pulp described by the patient through clinical symptoms. Studies discuss the possibilities of sickle cell patients, such as anemia patients, presenting a diverse predisposition to pulp disorders. This study aims to perform a thorough literature investigation to explore the connection between aspects involving iron deficiency anemia and dental pulp disorders. A literature review is formally described as a systematic gathering process and consolidating past research. 71 articles published in English from PubMed, Wiley Library, Science Direct and Scholar Google were analyzed. People with iron deficiency anemia frequently present manifestations such as fatigue and paleness, which can reflect oral issues such as gum inflammation and a more increased incidence of cavities, which can advance to affect the dental pulp.

Keywords: Biofilm, Endodontics, Public Health Practice, Oral Health.

RESUMO

Anemia é um problema de saúde significativo em todo o mundo devido à escassez de glóbulos vermelhos ou hemoglobina. Um desequilíbrio devido à deficiência de ferro leva à anemia, que tem consequências adversas que impactam negativamente o corpo e a saúde bucal. Patologia pulpar é o termo genérico usado na descrição de doenças

pulpares como um conjunto morfofuncional. O diagnóstico clínico depende da correlação de informações sobre o estado inflamatório da polpa dentária descrito pelo paciente por meio de sintomas clínicos. Estudos discutem as possibilidades de pacientes com anemia falciforme, como pacientes com anemia, apresentarem uma predisposição diversa para distúrbios pulpares. Este estudo tem como objetivo realizar uma investigação bibliográfica completa para explorar a conexão entre aspectos envolvendo anemia ferropriva e distúrbios da polpa dentária. Uma revisão bibliográfica é formalmente descrita como um processo sistemático de coleta e consolidação de pesquisas anteriores. Foram analisados 71 artigos publicados em inglês do PubMed, Wiley Library, Science Direct e Scholar Google. Pessoas com anemia ferropriva frequentemente apresentam manifestações como fadiga e palidez, que podem refletir problemas bucais como inflamação gengival e uma incidência maior de cáries, que podem avançar para afetar a polpa dentária.

Palavras-chave: Biofilme, Endodontia, Prática de Saúde Pública, Saúde Bucal.

RESUMEN

La anemia es un problema de salud importante en todo el mundo debido a la escasez de glóbulos rojos o hemoglobina. Un desequilibrio debido a la deficiencia de hierro conduce a la anemia, que tiene consecuencias adversas que afectan negativamente al cuerpo y la salud bucal. La patología pulpar es el término genérico utilizado en la descripción de las enfermedades pulpares como un conjunto morfofuncional. El diagnóstico clínico se basa en la correlación de la información sobre el estado inflamatorio de la pulpa dental descrito por el paciente a través de síntomas clínicos. Los estudios discuten las posibilidades de que los pacientes con anemia falciforme, como los pacientes con anemia, presenten una predisposición diversa a los trastornos pulpares. Este estudio tiene como objetivo realizar una investigación exhaustiva de la literatura para explorar la conexión entre los aspectos que involucran la anemia por deficiencia de hierro y los trastornos de la pulpa dental. Una revisión de la literatura se describe formalmente como un proceso sistemático de recopilación y consolidación de investigaciones anteriores. Se analizaron 71 artículos publicados en inglés de PubMed, Wiley Library, Science Direct y Scholar Google. Las personas con anemia por deficiencia de hierro presentan con frecuencia manifestaciones como fatiga y palidez, que pueden reflejar problemas bucales como inflamación de las encías y una mayor incidencia de caries, que pueden avanzar hasta afectar la pulpa dental.

Palabras clave: Biopelícula, Endodoncia, Práctica de Salud Pública, Salud Bucal.

1. INTRODUCTION

Anemia is a significant health concern worldwide due to a shortage of red blood cells or hemoglobin (Obeagu *et al*., 2024). Anemia is detected in 4% of men and 8% of women and among middle-aged and elderly people. One of the common variants of anemia is anemia of chronic diseases (AHZ), anemia of chronic inflammation, or iron-distributing anemia, which occurs in patients with chronic activation of cellular immunity (Elstrott *et al*., 2020; Salokhiddinovna 2023).

Iron (Fe) is vital in various essential processes, including oxygen transport, deoxyribonucleic acid synthesis, metabolic energy, and cellular respiration (Cappellini *et al*., 2022). Although necessary for cellular life, excess iron can produce reactive oxygen species, which induce oxidative stress, lipid peroxidation, and deoxyribonucleic acid damage, compromising cell viability and stimulating 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). Several studies suggest that iron deficiency anemia (IDA) is the most common nutritional deficiency in the world, affecting up to 2 billion people (Bahdila *et al*., 2019)

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).

When it comes to pulp diseases, Behruz & Bahodir (2024) clarify that pulp pathology is the generic term used in the description of pulp diseases as a morphofunctional ensemble. The clinical diagnosis relies on the correlation of information regarding the inflammatory state of dental pulp described by the patient through clinical symptoms, mainly pain, which together with other paraclinical data (dental radiographs) provide the basis for a therapeutic decision (Behruz; Bahodir 2024).

Bhat *et al*., (2021) also discuss the possibilities of sickle cell patients, such as anemia patients, presenting a diversity predisposition to pulp disorders. This study aims to perform a thorough literature investigation to explore the connection between aspects involving iron deficiency anemia and dental pulp disorders.

2. THEORETICAL FRAMEWORK

Iron is part of the subfamily of transition elements and is one of the most abundant metals on Earth and 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).

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 ID diagnosis is made, several treatment options exist (Auerbach and Adamson, 2015).

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.

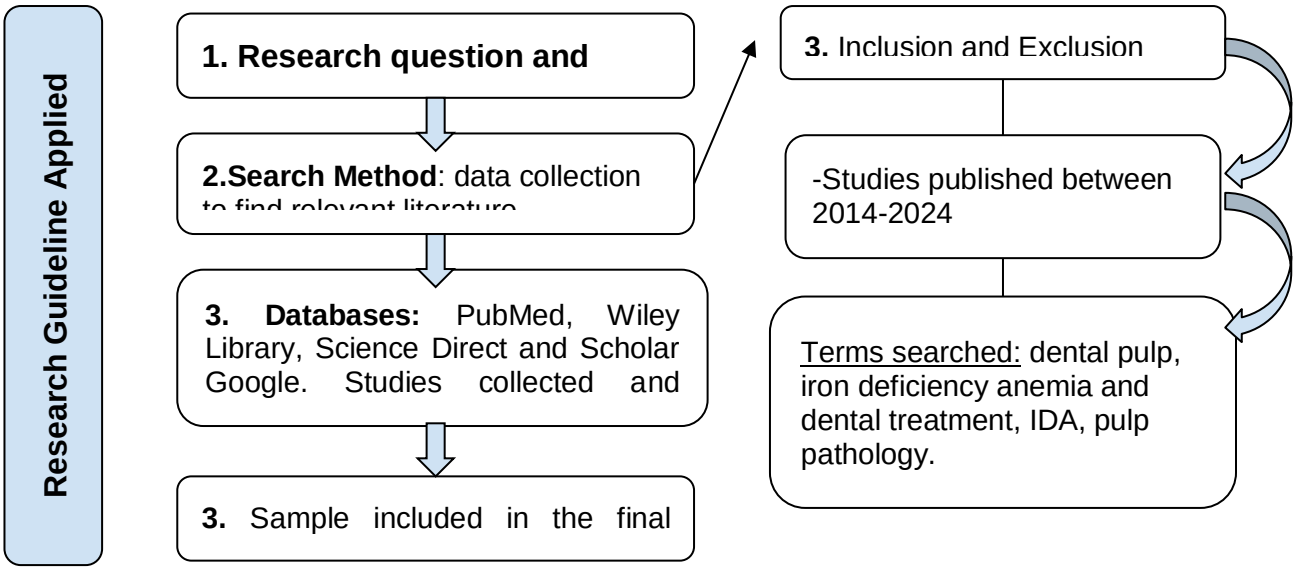
Iron deficiency represents the most prevalent nutritional deficit on a global scale. Iron deficiency anemia is an international public health problem that affects developed and undeveloped countries, with important consequences on individual health, quality of life, and society with health, social, and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

3. METHODOLOGY

A literature review is formally described as a systematic gathering process and consolidating past research. (Jesus *et al.*, 2024). To support an integrative literature review, (N= 71) articles published in English from PubMed, Wiley Library, Science Direct and Scholar Google were analyzed. After the assessment, only 24 articles published between 2014-2024 were comprised.

The terms searched were “pulp disorders” or “pulpitis” or “anemia,” or “oral health and anemia,” or “iron deficiency anemia” and “anemic oral patients” or “anemia and oral manifestations” or “pulp pathology” or “IDA,”. To identify empirical studies that have applied network analysis to investigate the process and to acquire the standard research, measures expressed in **Flowchart 1** were followed, as displayed:

Flowchart 1. Description of the methodology applied.



Source: elaborated by the authors (2024).

4. RESULTS AND DISCUSSIONS

Dental pulp represents a specialized connective tissue enclosed by dentin and enamel, the most highly mineralized tissues of the body (Behruz; Bahodir 2024).

For a long time, research has been carried out in dentistry on the development and improvement of pulpitis treatment methods that ensure the preservation of the pulp not only in a viable but also in a functioning state. Meanwhile, successful treatment is impossible without an accurate diagnosis of the pulp condition (Tahirovna, 2023).

Acute and chronic inflammation of the pulp causes pathological changes in the dentin of the tooth, manifested by dystrophy and necrosis of odontoblasts, which leads to the formation of foci of persistent microflora that penetrate the periapical tissues through the system of dentinal tubules (Tahirovna, 2023).

It's possible to affirm that diverse studies are trying to develop new perspectives about the relationship between iron deficiency anemia and processes concerning oral health, oral effects and how pulp disorders originate, samples of studies concluded between 2013 and 2024 are applied in table 1.

Table 1. Shreds of evidence and research regarding the primordial review topic.

Article Name	Author & Year	Conclusions and Studies Results
The effect of iron deficiency anemia on experimental dental caries in mice	BAHDILA et al., (2019)	Based on this experiment, we conclude that IDA markedly increases the caries susceptibility of mice. This tendency towards more destructive lesions was observed in IDA animals that were uninfected with *S. mutans*.
Association between iron status, iron deficiency anemia, and severe early childhood caries: a case-control study	SCHROTH et al., (2013)	Children with S-ECC appear to be at significantly greater odds of having low ferritin status compared with caries-free children and also appear 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.
Iron deficiency anemia as a risk factor for pulp disease in children from the central Peruvian jungle: a case-control study.	Leon-Rodriguez et al., (2024)	Anemia configures a risk factor for pulpal disease as 82% of pulp disease patients suffer from it.
Assessing the occurrence and severity of pre-and postendodontic pain in anemic and healthy female patients.	Kazemipoor *et al*., (2022)	Iron deficiency anemia is a contributing factor to the higher incidence of post-endodontic pain in women. Therefore, iron deficiency anemia can negatively influence pulp health by compromising oxygenation, immunological response and the repair capacity of pulp tissues.
Iron Deficiency Anemia and Its Impact on Oral Health—A Literature Review	Velliyagounder; Chavan; Markowit (2024)	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.
Iron deficiency anemia associated factors and early childhood caries in Qingdao	Shuaiqi et al., (2022)	Children with Iron Deficiency Anemia had higher rates and severe caries than those without it.
Iron deficiency anemia in children with and without dental caries: a systematic review and meta-analysis	Amrollahi & Tarrahi (2022)	Iron deficiency anemia was more prevalent in children with dental caries. Hemoglobin, MCV, and serum ferritin levels are lower in children with dental caries than in caries-free ones. Further high-quality research is recommended to gain a better insight into the association between dental caries and IDA in children.

Oral Findings in Sickle Cell Anemia Patient – A Case Report	Bhat *et al*., (2021)	Patients with Sickle cell disease can present with varied oral findings. The dental consultant should be aware of the difficulties in the diagnosis and management of pulpal necrosis in such patients.

Source: elaborated by the authors (2024).

Data has shown that IDA is inherently associated 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).

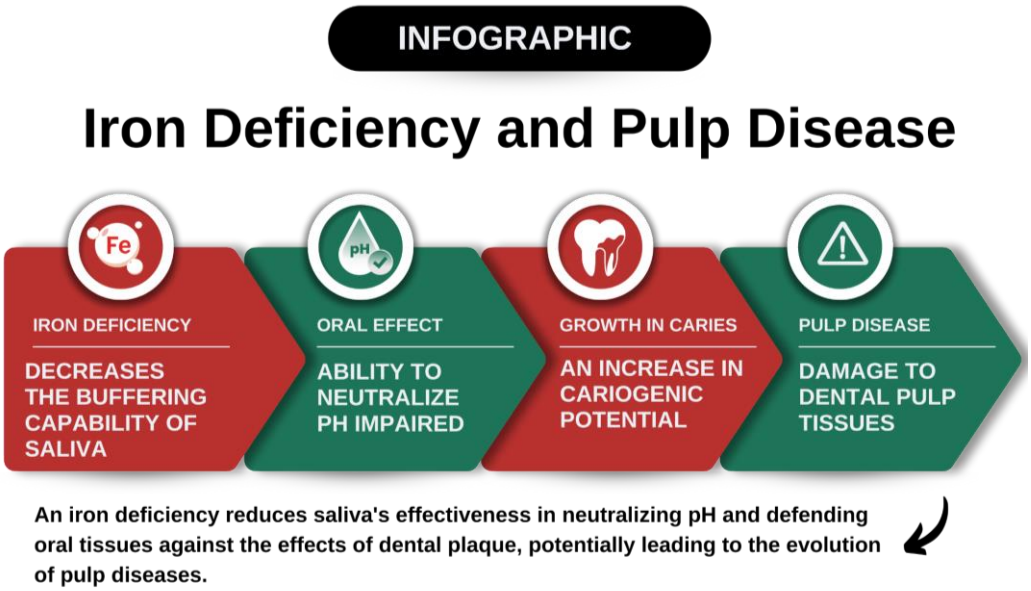
A complex theory by Abed *et al*., (2014) is that the low hemoglobin levels usually observed in children with caries may be attributed to the body's inflammatory reaction, which may accompany overgrown forms of dental caries (particularly those involving pulpitis or abscesses) as this inflammation may 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 (Schroth *et al*., 2013; Bansal et al., 2016).

Iron deficiency decreases the buffering capability of saliva, depriving it of its ability to neutralize 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 process is explained in **Figure 1**, as displayed:

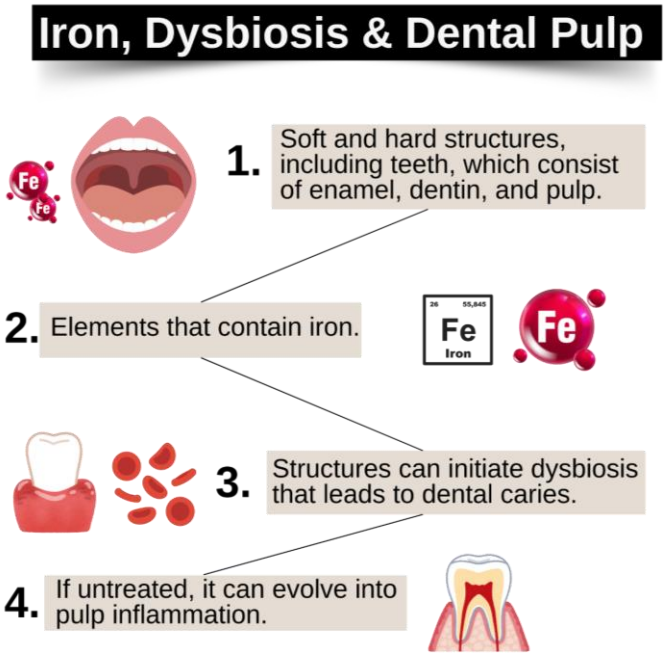
Figure 1. Iron deficiency decreases the buffering capability of saliva.



Source: elaborated by the authors (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 process is explained in **Figure 2**, respectively:

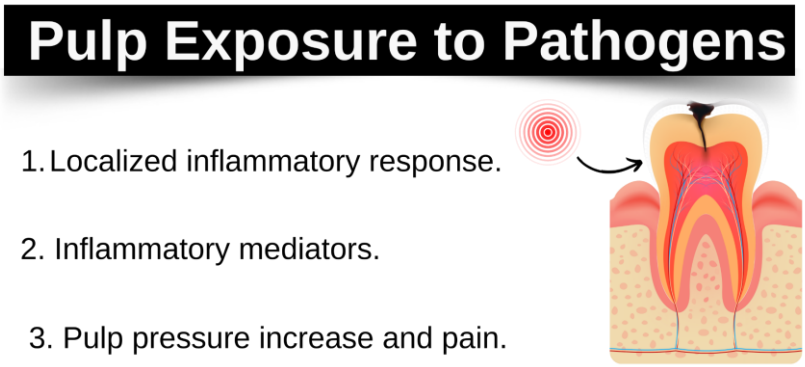
Figure 2. Process of dental pulp inflammation that can be influenced during the iron deficiency.



Source: elaborated by the authors (2024).

The pulp exposure to pathogens triggers a localized inflammatory response that releases inflammatory mediators. This process reveals pulp pressure increase, resulting in acute pain in patients, a characteristic symptom of pulpal disease (Leon-Rodriguez et al., 2024). The process is explained in **Figure 3**, as illustrated in three steps:

Figure 3. Pulp Inflammation Induced by Iron Deficiency.



Source: elaborated by the authors (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).

Currently, there is no existing research that explores the relationship between iron deficiency anemia and the responses observed in pulpal sensibility tests. Investigations suggest that anemic women have a lower threshold in their responses to the Electric Pulp Test (EPT) compared to those who are healthy (Kazemipoor *et al.*, 2022). Iron deficiency has been cited repeatedly as a factor contributing to the discoloration of primary teeth, and many parents regard this issue as an initial sign of caries development linked to the administration of iron supplements (Asgari; Soltan; Sadeghi, 2020).

Iron deficiency anemia can harm pulp health by causing reduced tissue oxygenation, impaired immune response, alterations in microvasculature, and decreased tissue regeneration capacity. These factors increase the susceptibility of dental pulp to diseases and infections, underscoring the matter of maintaining adequate iron levels for oral health. People with iron deficiency anemia frequently present manifestations such as fatigue and paleness, which can reflect oral issues such as gum inflammation and a more increased incidence of cavities, which can advance to affect the dental pulp (Kazemipoor *et al*., 2022).

5. CONCLUSION

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. Further studies are necessary to determine new breakdowns concerning the involvement between IDA and the pulp tissue, such as vascular aspects, microorganisms involved and microbiological analyses.

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