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Research Article

Early Childhood Caries: A Review of Diagnosis, Treatment and Consequences

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ABSTRACT

This review defines early childhood caries at young ages, with reference to its types and how to diagnose it correctly in its various stages. Also, the various preventive methods, which are especially important for children who are more susceptible to tooth decay due to the multiple causes. Various restorations and treatment methods have had excellent effectiveness in preserving primary teeth to prevent and reduce the negative consequences of tooth decay.

1. INTRODUCTION

Humans of all ages worldwide are affected by dental caries and remains a major dental health problem among school children. The interplay of cultural, social, behavioral, nutritional, and biological risk factors involved in its onset and progression makes it impossible to eradicate it [1].Dental caries is the term used to describe the effects, manifestations like signs and symptoms , and potential complications associated with localized demineralization of the inorganic portion and the destruction of organic tooth substances that begin on external tooth surface[2][3].The interaction of three primary factors over time: dietary carbohydrates, cariogenic bacteria within dental plaque, and susceptible hard tooth surfaces is what leads to this multifactorial disease[4].

The presence of dental caries in preschool children can be described by different terms, some of which are related to the etiology, such as nursing bottle caries, nursing bottle mouth, early infant tooth decay, and rampant caries. however, 'early childhood caries' is the most prevalent term used to explain the existence of any dental caries in children under the age of 6[5].

2. ETIOLOGY

ECC, like other carious lesions, is a result of inadequate oral hygiene, bacterial invasion, and poor nutritional behaviors. The interaction between pathogenic organisms, fermentable carbohydrate substrate, host susceptibility, and time is a key factor. If left untreated for long enough, cariogenic microorganisms in the presence of fermentable carbohydrates (such as sucrose) can lead to demineralization of tooth substance and eventually lead to loss of tooth structure or cavitation [1][6].

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2.1 Primary Etiological Risk Factors

2.1.1 Microbiological risk factors

The cariogenic microorganisms play an important role in caries development. Carious lesions are mainly caused by Streptococcus mutans (SM), an important pathogenic organism. Lactobacilli play a role in caries progression but not in its initiation [6].

2.1.2 Dietary risk factors

The model of caries is impacted by dietary factors in two ways: firstly, they affect the availability of fermentable carbohydrates needed for acid formation to start caries; secondly, they affect host susceptibility due to prenatal and early infant nutrition influencing primary teeth enamel development [7][8]. Both S. mutans and lactobacilli metabolize sugar, converting it into acids that lead to the demineralization of the tooth structure. Sucrose, which is the most commonly used sugar, is considered the most crucial substrate for cariogenic bacteria to establish due to its ability to promote bacterial adhesion to teeth [3]. Additionally, if children with chronic diseases use saccharose-containing oral medication without oral rinsing and cleaning after administration, which occurs due to the high sugar load in the medication, they can be at risk of ECC [9].

2.1.3 Susceptible tooth/host

Various factors may increase the susceptibility of a specific tooth to developing dental caries. The presence of enamel defects, reduced saliva, and immunological factors are all risk factors for caries development in hosts [10].

- Saliva
  Saliva provides the main host defense systems against dental caries by clearance of foods and the buffering of dental plaque's acid. Saliva also eliminates bacteria by several antimicrobial proteins, including lysozyme, lactoferrin, agglutinins. It also functions as a mineral reservoir for calcium and phosphate necessary for enamel remineralization [11]. Development of dental caries depends on the amount of saliva and composition of its secretion. During sleep, the tooth is more susceptible to caries due to reduction in flow rate of saliva decrease its buffering capability [12].
- Immunological Factors
  Since enamel lacks immunological activity, the primary immune defenses against S. mutans are salivary secretory immunoglobulin A (IgA), serum, and gingival crevicular fluid. Salivary IgA antibodies develop as children become exposed to oral microorganisms [1].
- Tooth Maturation and Defects
  Deficiencies in mineralization due to developmental disturbances of tooth germ may allow additional plaque accumulation on smooth surfaces and increase risk of ECC in children. The characteristics of defects include Hypoplasia, immature enamel, tooth morphology including size, surface texture, and depth of fossae and fissures as well as genetic traits and the presence of crowded or malaligned teeth [1][13].

2.1.4 Dental plaque

The salivary pH fluctuates due to the metabolic activity of bacteria in the biofilm. Organic acids are produced by cariogenic plaque bacteria through the fermentation of carbohydrates, which cause caries on a susceptible tooth [11].

2.2 Secondary Etiological Risk Factors

2.2.1 Infant feeding patterns

Nursing caries is a type of rampant caries affecting the primary teeth of young children, which may show up at nine months of age and has been linked to prolonged bottle or breast feeding [14]. Breastfeeding is the ideal nutrition for infants, but excessive and repeated contact with human milk results in acidic conditions and softening of enamel. These conditions were explained by reduced salivary flow during sleep, which decreased the neutralization capacity of saliva, causing food to stagnate around the teeth and increasing the duration of fermentable carbohydrate exposure [15].

2.2.2 Oral hygiene

The presence of dental plaque is a significant risk factor for developing caries in young children. Therefore, dental caries occurance is depends on brushing habit, frequency of brushing, and/or use of fluoride toothpaste. Tooth brushing breaks the dental biofilm and reduces bacterial numbers, while the fluoride in toothpaste remineralize carious lesions [16].

2.2.3 Socioeconomic status

The majority of children with ECC are those who live in poverty or in poor economic conditions, are born to single mothers, and have low educational levels. Prenatal and perinatal malnutrition in these populations puts children at risk of enamel hypoplasia, and their exposure to fluoride is probably insufficient, and there is a greater preference for sugary

foods. Due to the fact that children in deprived communities commonly delay the start of tooth brushing and brush less often, often visiting the dentist for the first time at a later age [15][17].

3. CLINICAL PRESENTATION OF EARLY CHILDHOOD CARIES

The clinical appearance of the teeth in a child 2, 3, or 4 years of age is typical and follows a definite pattern. There is early carious involvement of the maxillary anterior teeth, the maxillary and mandibular first primary molars are more susceptible to caries and sometimes the mandibular canines. The mandibular incisors are typically protected and remain unaffected due to salivary flow from the sublingual and submandibular glands, as well as the covering provided by the tongue [3][18]. ECC begins as a band of white decalcification along the gingival line or on the occlusal surface of teeth. The interesting feature of an early carious lesion of enamel is that the lesion is subsurface; that is most of the loss of mineral occurs beneath an intact enamel surface. This is the pre-cavitation stage (white opaque lesion) (figure 1. A). As the process of demineralization progresses, the enamel surface breaks down, and the cavity is created which can turn yellow (figure 1. B), brown or black. As the lesion progresses, it will extend around the tooth, forming a black discoloration (figure 1. C) with extensive hard tissue loss. This renders the tooth susceptible to crown fracture [19].

Fig. 1. A. white opaque lesion, B. Active carious lesion with yellowish color, C. Progressed lesions with black discoloration

4. CLASSIFICATION

Several researches have attempted to develop classification systems for early childhood caries.

4.1 Classification based on the stage of development of the dentition and the severity of dental caries:

Veerkamp and Weerheijm (1995) [20] classified ECC into 4 stages as follows: -

- Stage I: Initial reversible stage (10–18 months)
  - chalky white demineralized areas, typically seen on cervical and sometimes interp.
  - roximal surfaces (figure 2).
  - No associated pain.

Fig .2. Initial reversible stage

- Stage II: Damaged carious stage (18–24 months)
  - Lesions appear on the maxillary anterior teeth and may extend into the dentin, often with a yellowish-brown discoloration (Figure 3).
  - Pain with cold.

Fig .3. Damaged carious stage

- Stage III: Deep lesion (24–36 months)
  - According to eruption time, cariogenic potential of sugar and eating frequency, this stage may develop within 10–14 months.
  - Molars are commonly involved.
  - Frequent complaint of pain.
  - Pulp damage in maxillary incisors (figure 4).

Fig .4. Deep lesions

- Stage IV: Traumatic stage (36–48 months)
  - Teeth fracture due to caries weakness.
  - history of trauma.
  - Pulpal damage in molars.
  - Necrosis in maxillary incisors (figure 5).

Fig. 5. Traumatic stage

4.2 Classification based on severity and etiology (Wyne, 1999)[21]

- Type I (mild to moderate): -
  1. isolated carious lesion in molars and incisors (figure 6).
  2. Increase in number of carious teeth due to cariogenic challenge.
  3. Caused by a combination of cariogenic food and inadequate oral hygiene.
  4. Children 2–5 years old.

Fig .6. Initial lesions of ECC

- Type II (moderate to severe): -
  1. Carious lesion labiolingualy in maxillary incisors (figure 7).
  2. Mandibular incisors remain unaffected.
  3. Feeding bottle or breastfeeding or a combination of both.
  4. Seen shortly after eruption of teeth.

Fig .7. Advanced lesions of ECC

- Type III (severe): -
  1. Dental decay involving all teeth, even the lower incisors (figure 8).
  2. Caused by cariogenic diet with poor cleaning habits.
  3. It is rampant.

Fig .8. Severe lesions of ECC

5. DIAGNOSIS

Diagnosis of early childhood caries involves the use of visual, clinical, and radiographic evaluation of children who are at risk.

5.1 Visual and Clinical Examination

The enamel surface can be examined through visual inspection and probing but it is not recommended because the probe has the potential to transfer cariogenic microorganisms from one site to another and damage the integrity of the enamel surface, which Can encourage the development of caries [22]

5.2 Radiographic Examination

The large contact points of primary teeth make the diagnosis of interproximal caries difficult. Therefore, bitewing radiographs are an important aid in the detection of interproximal caries and are recommended for posterior teeth. If a child is uncooperative with a bitewing radiograph, a bimaxillary oblique view may be obtained. Periapical radiographs are recommended for teeth with invasive caries or pulp involvement [22].

6. PREVENTION

The AAPD (2016) [23] advocates for both professional and at-home preventive care that include recommendations about:-

1. Avoid excessive consumption of liquids and/or solid foods that contain sugar. Additionally, avoid breastfeeding after the first primary tooth starts to erupt and baby bottle use after 12-18 months.
2. It is important to implement oral hygiene measures at the time of eruption of first primary tooth. Parents are responsible for brushing their teeth two-time aday, using a soft toothbrush.
3. Providing professional application of fluoride varnish treatments for children who are at risk of ECC.
4. A caries risk assessment for preventing oral diseases can be conducted by establishing a dental home within six months of eruption of the first tooth and no later than 12 months of age
5. Work with health care providers to ensure all infants and toddlers have access to dental screening, counseling, and preventive measures.
6. Raise awareness among legislators, policy makers, and third parties about the consequences of ECC and prevention strategies.

6.1 Preventive Measures

6.1.1 Fluoride

Fluoride effectiveness is dependent on adherence, whether through toothpaste or access to dental care or funding (fluoride varnish or water fluoridation) [24]. During tooth development (up to seven years of age), fluoride is absorbed and ingested into tooth structure, making the teeth stronger against acid attacks [25]. The progression of tooth decay can be prevented and slowened by fluoride, and early lesions can be reversed [26].

6.1.2 Chlorhexidine

It has antibacterial properties that is act as an antiseptic. Chlorhexidine salts dissociate to produce the positively charged CHX cation. The bactericidal effect is the result of this cationic molecule binding to the negatively charged bacterial cell walls. CHX is being studied for its potential to prevent and inhibit dental caries [27]. A clinical trial conducted in children demonstrated that combining chlorhexidine varnish with fluoride varnish was more effective in enhancing the remineralization of white spot lesions after three months, compared to using the same active agents individually [28].

6.1.3 Casein phosphopeptide-amorphous calcium phosphate

It represents one of the remineralization systems based on calcium phosphate, capable of supplying calcium and phosphate ions that act as reservoirs. These ions help neutralize plaque acidity, sustain a supersaturated environment around the enamel, and thereby support the remineralization process effectively [29].

6.1.4 Xylitol

It is a non-fermentable sugar alcohol that serves as sweetening agent. It has an antibacterial capacity against Streptococcus mutans [30]. Its positive effects are that it is not metabolized by cariogenic bacteria and has antibacterial properties. Daily use of xylitol wipes (Figure 9) has been shown to significantly reduce the incidence of dental caries in young children. In addition, mothers who chewed xylitol gum during the first two years of their children's lives had significantly reduced SM colonization and less caries after five years [31].

Fig. 9. Wipes wrapped on index finger and Procedure of wipes usage

7. TREATMENT

Treatment of early childhood caries depends on many factors also depends on the patient's and parents' motivation for dental care, the severity of caries, the child's age and cooperation [32].

7.1 Minimal Invasive Dentistry

- MID approach for non-cavitated lesions: -The treatment of non-cavitary lesions is recognized as a non-invasive procedure that slowing the progression of the disease by stopping demineralization and promoting remineralization. This approach entails both enhancing exposure to protective factors and reducing exposure to risk factors. It encompasses clinical interventions, such as fluoride-based treatments, alongside home-based measures implemented by the patient or caregiver, including control of sugar intake and maintenance of oral hygiene [33].
- MID approach for cavitated lesions: -Treatment include creating a hostile environment for the cariogenic biofilm (e.g., using silver diamine fluoride) or preventing biofilm access to the lesion by sealing it, as done in atraumatic restorative treatment (ART) or with Hall technique crowns. The preservation of primary teeth and their structure is possible through these techniques while minimizing the risk of child disturbance [34].

7.1.1 Arrest of Caries Treatment

Since the 1940s, silver-based materials have been developed and employed in dental treatments for various purposes, including caries prevention, caries disinfection, and dentin desensitization [28]. Stopping caries lesions using silver diamine fluoride (SDF) (Fig. 10) probably occurs due to a combination of antibacterial effects. It combines the anti-cariogenic properties of both silver and fluoride. Half of previously active lesions can be stopped by a single application of SDF, and three-quarters can be stopped by semi-annual use [35]. Another advantage of ACT is that it allows for future placement of conventional restorations. Studies have shown that glass ionomer cement (GIC) and composite restorations can be successfully applied following SDF treatment without compromising bonding effectiveness [36]. SDF is considered safe for young children, with no serious side effects reported in the literature. The common minor side effect is a slow darkening of caries lesions following application of SDF (Figure 11) Caregivers should be advised of this discoloration prior to use; therefore, discoloration of posterior teeth is considered to be better tolerated than discoloration of anterior teeth. Temporary discoloration may also occur on soft tissues, such as the lips, as well as on the fingers or skin, if not applied with proper care [37]. The arrest rates seem to vary greatly depending on the solution’s concentration and the frequency of SDF usage, and the necessity of cleaning and drying before application [35]. SDF is currently recognized as an effective preventive and therapeutic agent for managing dental caries in preschool children, owing to its safety, simplicity, affordability, and proven efficacy [38].

Fig. 10. SDF material

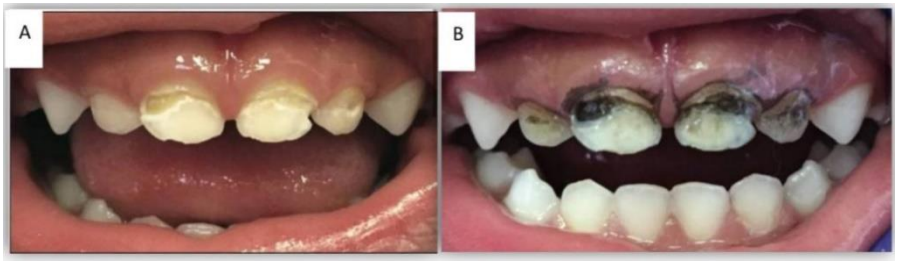

Fig. 11. A. Active cavitated caries lesions before application of SDF, B. SDF-treated lesions with staining

7.1.2 Atraumatic restorative treatment

It is a painless restorative treatment that does not require local anesthesia or drilling. The ART technique consists of removing carious tissue using manual instruments, followed by filling the cavity with a high-viscosity glass ionomer cement (GIC), known for its chemical bonding to tooth surfaces, fluoride release, and biocompatibility [28]. Fluoride can be released from the glass ionomer for up to five years. This property of GICs means that teeth treated with ART are less prone to caries over the long term [39]. Incomplete removal of carious dentin was observed in prepared cavities, fluoride still penetrated into the remaining carious dentin underneath and the glass ionomer remained attached to the tissue [40]. Although two-surface ART restorations have higher success rates, Studies have shown that single-surface ART restorations in deciduous teeth achieve similar long-term outcomes to conventional dental restorations [41].

7.1.3 The hall crown technique

Stainless steel crowns are considered the most effective restoration for managing large caries in primary teeth. However, traditional techniques require preparing the tooth and administering local anesthesia. On other hand, the Hall technique (Figure 12) consist of placing a stainless-steel crown over a carious primary molar that has not been previously prepared. By sealing the caries under the crown, the progression of dental caries is effectively arrested, and usually, no more intervention is needed [42]. Patients experience less discomfort after the Hall technique than with traditional restorations [43].

Fig.12. Hall crown (preformed metal crown cemented without local anesthesia, caries removal or tooth preparation (Hall Technique)

7.2 The Conventional Treatment Approach

Traditional treatments for caries in primary teeth include: Use of local anesthesia, cavity preparation, reconstruction with various filling materials, crowns, pulp therapy (pulpotomy and pulpectomy), and extraction. These procedures are beneficial for the family, and the child. They present a challenge to the dental team. Traditional restorative materials include amalgam, composites, compomers, glass ionomer cements (GIC), resin modified GIC (RMGIC), and stainless-steel crowns[44].

- Direct restorative materials: -

According to AAPD (2016) [44] guidelines, composites, compomers, and RMGICs are recommended materials for use in Class I cavity restorations. However, GIC and RM-GIC restorations have the benefit of releasing fluoride into the dental tissues, reducing the chance of new lesions developing along the edges of the restoration, and increasing the tooth's resilience against caries [45]. Many studies have shown that amalgam restorations on primary teeth have a longer life span than tooth-colored restorations, especially GICs [46].

- Preformed restorations: -
  Traditional stainless-steel crowns are the most reliable restoration for primary molars that have undergone pulp treatment or when the tooth is severely decayed. They are also recommended for young children who are at high risk for tooth decay, as tooth-colored or amalgam fillings can fail and cause further decay [47]. However, crowns are expensive, and some parents object to their appearance. Tooth-colored crowns have gained popularity in recent years for restoring primary molars and incisors. However, available research on their clinical success remains limited, and their cost is significantly higher compared to conventional stainless steel crowns [33].
- Pulp therapy for primary teeth: -
  Primary teeth may require treatment or extraction, and the practitioner may need to consider various factors involve an accurate diagnosis of the pulp status, a comprehensive evaluation of the tooth's significance in child's development, the tooth's restorability, the child's age, and their level of cooperation [47]. If the pulp is irreversibly infected, options are limited to root canal treatment or extraction. If the vital pulp is not symptomatic or extraction. In cases where there is asymptomatic or reversible inflammation in the vital pulp, treatments such as indirect pulp therapy, direct pulp capping or pulpotomy may be considered [33]. When primary teeth have pulp necrosis or an abscess, extraction is usually recommended.
  If the extraction occurs close to the time the permanent successor is expected to erupt (within a year), space is usually maintained. However, if eruption is delayed especially after removing a first or second primary molar space loss can occur, making root canal treatment and preserving the tooth a better option [33].

8. CONSEQUENCES OF EARLY CHILDHOOD CARIES

Early childhood caries does not heal naturally. Delayed treatment can worsen a child's condition, increasing the risk of pain and discomfort, the formation of abscesses, and the development of additional carious lesions in both primary and permanent dentitions, risk of delayed physical growth and reduced physical activity and quality of life related to oral health. This can lead to bacteremia, premature tooth loss, speech disorders, high fees, impaired self-confidence, and subsequent negative effects on permanent teeth [3].

9. CONCLUSION

Early childhood caries remains a highly prevalent worldwide disease that has a considerable impact on individuals and communities. While it is not life- threatening, it has high costs to society and a major impact on parents and children, leading to pain, functional impairment, and negative effects on the child's growth, body weight, and overall development, ultimately diminishing their quality of life. Intervention strategies rang from modifying individual behaviors and engaging families and caregivers, to broader public health measures such as developing health policies, fostering supportive environments, promoting health, and reorienting health services toward disease prevention. In the clinical management of Early Childhood Caries (ECC), non-cavitated lesions should be halted and remineralized, while cavitated lesions should be treated using minimally invasive approaches that prioritize tooth structure preservation and aim to prevent unnecessary extractions. Ultimately, dental professionals should prioritize the use of current diagnostic techniques to detect lesions early, identify carious teeth, and provide appropriate guidance for the prevention of early childhood caries.

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