

Research Progress on Caries

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Abstract. Caries is one of the most common diseases in the human body, and its incidence is extremely high in both children and adults. Caries is also a chronic and developmental disease, and its sustainable development will not only seriously endanger oral health, but also endanger the health of the whole body. At present, some progress has been made in the research on the pathogenesis and prevention of caries, but there are still many problems to be solved. This paper discusses the etiology, treatment and prevention of caries, aiming to lay a foundation for the prevention and treatment of caries.

1. Introduction

Caries is one of the most common diseases in the human body. It is a chronic disease that dental hard tissue is gradually destroyed under the action of multiple factors. According to statistics, the incidence of caries in children reached 60.1 % [1], while 80% of the people in the world are affected by caries [2]. Caries is characterized by inorganic demineralization and organic matter decomposition from the crown, and are accompanied by changes in the clinical characteristics of tooth color, shape and texture. Caries do not show obvious symptoms in the early stage, but as the disease progresses, the lesions will experience persistent or intermittent pain, and are sensitive to stimuli such as cold, heat, acid, and sweetness [3]. In the late stage of caries, the affected tooth is even lost. Therefore, if caries is not treated in time, the quality of life of patients will be affected. Caries not only endanger oral health, leading to periodontitis, pulpitis and maxillofacial deformities, but may also be complicated by systemic diseases such as systemic inflammation, malnutrition, anemia and psychological disorders. According to three national oral health epidemiological surveys in 1983, 1995 and 2002, caries is still a common and high incidence disease in human oral diseases.

In the past 20 years, the prevalence of dental caries has changed little [4], which shows that people's understanding and attention to caries have increased slowly, and its high incidence also reflects the lack of people's oral health awareness. The etiology of caries is complex, and there is no clear scientific knowledge about the pathogenesis of caries at present. According to previous studies, the occurrence of caries is mainly influenced by four main factors: time, food, microorganism and host [5]. Studies have shown that the occurrence of caries begins with the formation of dental

plaque [6]. At present, the prevention and treatment of caries mainly include drug prevention and surgical treatment. Commonly used drugs include fluoride, silver nitrate [7] and tea polyphenols [8]. According to the research, tea polyphenols can effectively inhibit the occurrence of caries [8]. Commonly used surgery includes pit and fissure closure, filling technology, root canal therapy, carisolv chemical mechanical caries removal method, non-traumatic filling therapy, etc., as well as immunotherapy methods that have not yet been applied to clinical practices on a large scale. In addition, the early detection methods of caries include quantitative photoinduced fluorescence technology, photothermal radiation technology and optical fiber transmission method.

Understanding the pathogenesis of caries, early detection of caries and curbing its development can better avoid the harm caused by caries. This article will discuss the etiology, treatment and prevention of caries in order to lay the foundation for further research and development of caries.

2. The etiology of caries

Due to the complex etiology of caries, the current scientific research has not fully elucidated the pathogenesis of caries. According to previous research results, the current pathogenic factors of caries mainly include internal factors and external factors.

2.1 External factors

2.1.1 Family impact

Family income and parents' educational level will affect the caries rate of children [9]. In families with higher incomes, the probability of children's exposure to sugary

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foods and snacks is also higher, resulting in an increase in caries incidence. But at the same time, good economic level provides economic basis for children's caries examination and treatment. Parents are highly educated and often have a higher level of awareness of dental caries, thus paying more attention to children's oral health and providing more timely treatment for children with caries. Moreover, the impact of the family on children is usually long-term and sustained.

2.1.2 Oral hygiene habits

The occurrence of caries is closely related to living habits. Studies have shown that the caries rate is closely related to patients' brushing condition, such as the age at the beginning of tooth brushing, the frequency of tooth brushing every day, the duration of tooth brushing each time, the frequency of mouthwash and whether fluoride toothpaste is used [10]. Correct tooth brushing can effectively reduce the attachment rate of dental plaque [11] and inhibit the formation of an oral environment prone to caries. An unhealthy oral environment can lead to a change in the acid-base balance of the oral cavity, forming an environment in which bacteria are easy to multiply, while leading to the caries rate greatly improved.

2.1.3 Dietary habits

Excessive intake of sweets can lead to a much higher prevalence of caries. The bacteria in the mouth interact with carbohydrates in the food, producing acidic substances, reducing the pH value of the tooth surface, thereby damaging the enamel and decalcification of teeth, thus making it easier to form caries [12]. At the same time, eating sweets before sleeping will accelerate the occurrence of caries, which is due to the weakening of oral saliva flow and the weakening of tooth erosion during sleep, so that bacteria are more susceptible to attachment [13]. The length of food retention time is positively correlated with the incidence of caries, that is, the longer the food remains in the mouth, the higher the probability of caries [14].

2.1.4 Age factors

Caries disease has a clear correlation with age. Before the age of 2, the caries rate was low, only about 20%. With the increase of age, the incidence of caries increased significantly and peaks at age 6 to 8 years. After 6 to 8 years of age, the rate of caries decreases with age. This is due to the loose structure of the dentition in children between the ages of 6 to 8 years, which provides conditions for the occurrence of caries [15].

2.2 Internal factors

2.2.1 Quadruple factors

Quadrupartites that cause caries include bacteria, host, time, and food [16]. When the host eats, food residues are fermented by cariogenic bacteria such as Streptococcus mutans in the mouth to produce acidic substances. Under the action of time, dental hard tissue is gradually destroyed, resulting in caries.

2.2.1.1 Bacteria

Bacteria are the most important factors leading to dental caries. Among them, the main cariogenic bacteria is Mutans Streptococ-ci, which belongs to gram-positive anaerobic bacteria. Mutans Streptococ-ci can strongly adhere to the tooth surface, and has the ability to decompose and ferment a variety of carbohydrates into acidic substances. At the same time, its acid resistance is also very strong, it can still maintain normal physiological activity for a long time under low pH conditions. The high-yield acidity and acid resistance of Mutans Streptococ-ci make it have a strong cariogenic ability [17]. In addition, Lactobacillus also has strong acid-producing and acid-resistance abilities, which is not caries-causing alone, but the synergistic effect with Mutans Streptococ-ci can promote the occurrence of caries [18].

2.2.1.2 Host

The saliva in the host mouth has a certain effect on caries prevention. Saliva has a fast flow, which can flush food residues, reduce their retention time in the mouth, and prevent the formation of dental plaque. At the same time, saliva can dilute the acidic substances on the tooth surface to prevent the occurrence of caries. In addition, saliva contains immunoglobulin and phosphate that can inhibit cariogenic bacteria, which is a good anti-cariogenic substance [6].

The susceptibility of host teeth also affects the prevalence of caries. Teeth susceptibility refers to the degree of calcification and quality of teeth [19]. The rate of caries is affected by factors such as the degree of calcification of the teeth, the arrangement of the teeth, and the development of the crown.

2.2.1.3 Time

The occurrence of caries is not a short process, but a long-term slow process from superficial to deep. The formation of caries includes multiple stages, such as tooth eruption, acid production, plaque attachment and mineralization of dental hard tissue, and each stage requires a certain amount of time [5].

2.2.1.4 Food

When refined food is ingested, the originally neutral oral environment will be acidified due to the action of bacteria, forming plaque. Plaques stay on the tooth surface for a

long time, which will lead to caries. On the contrary, rough food has a clean anti-caries effect on teeth. Therefore, appropriate intake of rough food can effectively prevent caries.

3. The treatment of caries

Caries can endanger oral health, and induce a variety of systemic inflammation and anemia, so the timely treatment of caries is very necessary. The occurrence of caries can be divided into three stages, shallow caries, middle caries and deep caries. Corresponding targeted treatments should be adopted at different stages.

3.1 Treatment of shallow caries

In the early stage of caries, the use of milder means can stop its further development, such as pit and fissure closure and the use of drug therapy.

3.1.1 Fissure closure

Fissure closure means that the sealant is applied to the deep groove of the tooth, and a barrier is formed after it is completely hardened, this process does not damage the tooth tissue. Fissure closure can control early caries and have a good inhibitory effect on its development[5]. After the pit and fissure were closed, the bacteria could not enter the pit and fissure, and the original bacteria in the pit and fissure lost their nutritional sources, and gradually died, so as to achieve the effect of treating shallow caries. But over time, pit and fissure sealant may fall off, which can affect the effectiveness of pit and fissure sealant[20].

3.1.2 Drug therapy

At present, drugs for caries mainly include fluoride and silver nitrate.

Fluoride treatment of caries can be divided into the topical and systemic applications of fluoride. In terms of topical application, the most commonly used clinical method is to add fluoride to the organic solution, and then rub it on the affected area. The fluoride in the solution reacts with the calcium phosphate salt in the tooth to form a fluoride mineral salt, which promotes the remineralization of the tooth, thus protecting the enamel and inhibiting the cariogenic bacteria. Other topical applications of fluoride also include the use of fluoride-containing gargles and fluorine-coated protective paint[21]. The treatment of caries with systemic fluoride mainly includes water fluoride regulation, salt fluoride and milk fluoride[22]. It is reported that systemic fluoride application can effectively treat caries[23]. In the 20th century, Danish researchers conducted a pilot project on drinking water fluoride, the results showed that the caries rate of children in the pilot area was significantly reduced. However, although the method of adding fluoride to drinking water is feasible, the concentration of fluoride is difficult to control. If fluoride concentration is too high, it is easy to cause dental fluorosis[19]. Therefore, at present,

the topical application of fluoride is easier to operate and safe and reliable.

Silver nitrate is an anti-corrosion fungicide, which has anti-corrosion, sterilization and astringent effects. For shallow caries, silver nitrate can be dipped in a cotton ball, repeatedly applied to the affected area for 1 to 2 minutes, and repeatedly after blowing dry. Then rub with clove oil or a small amount of 10% formalin (4% formaldehyde content) to achieve the effect of inhibiting bacterial reproduction. In addition, silver nitrate therapy can cause tooth staining and affect tooth aesthetics, so the therapy is usually used for the treatment of posterior teeth[7].

3.2 Treatment of middle and deep caries

For moderate and deep caries, simple drug therapy has been unable to achieve the desired effect, and surgical intervention is needed. Common surgical methods include filling therapy, root canal therapy, laser therapy and Carisolv MediTeam Dental.

3.2.1 Filling therapy

Filling therapy mainly includes filling inlay and non-traumatic filling therapy.

This method first completely removes the diseased tissue or suspended enamel to form a specific pore type, then cleans and disinfects the holes, and then fills the holes with materials such as silver amalgam or resin to curb the development of caries and restore the anatomical form of the teeth. For medium and deep caries, a pulp protector is applied after the caries is removed to protect the pulp [24].

Atraumatic restorative treatment (ART) is also one of the commonly used methods for the treatment of caries. This method first uses instruments to remove the decay of caries, and then uses new ionic materials with good wear resistance and pressure resistance to filling caries [25]. The new material contains fluoride ions, over time, can promote dentin hardening, so as to achieve the purpose of treatment of caries[24]. This method is simple to operate and non-invasive and painless, so it is widely used in clinical practice.

3.2.2 Root canal therapy

When caries progresses to the pulp and periapical periodontal, pulpitis and periapical periodontitis are caused, root canal therapy is often needed to intervene[26]. Root canal therapy includes tooth preparation, root canal orifice location, pulp extraction, root canal medication and root canal filling. The entire treatment of the root canal requires preoperative film, intraoperative initial apical film, main apical film and root filling complete film, and postoperative follow-up[27]. Root canal therapy can repair residual crowns and roots, prevent caries from further damaging oral health and maintain the integrity of dentition[28].

3.2.3 Laser therapy

Laser therapy refers to the use of Er : YAG laser to produce "micro-explosions" to remove the target tissue. Laser treatment can protect enamel, dentin and pulp while removing saprophytes. Laser sterilization has the advantages of being minimally invasive, low noise, painless and wide range of applications. According to the survey, children are more receptive to laser treatment, which is due to the fact that laser therapy can effectively reduce children's fear of dental caries treatment[29].

3.2.4 Carisolv MediTeam Dental

Carisolv chemical mechanical caries removal system (Carisolv MediTeam Dental, Gothenburg, Sweden) is the latest minimally invasive technology and has a good effect on the treatment of caries[30]. Carisolv caries treatment effect as shown in Figure 1[31]. In this method, the special carisolv gel was smeared on the dental caries site, and the caries dentin was selectively softened. and then uses a special manual instrument to gradually scrape it off, which can selectively remove the carious part. Carisolv MediTeam Dental has the advantages of almost painless, low noise and little tooth damage, which can effectively help the elderly and children overcome the fear of seeing a doctor.



Figure 1. Imaging of Carisolv before and after caries removal
A: Before caries removal (electron microscope magnification 500 times)
B: Carisolv after caries removal (electron microscope magnified 500 times)
C: Carisolv after caries removal (electron microscope magnified 1500 times)

4. Prevention of caries

4.1 Means and substances for caries prevention

4.1.1 Means of caries prevention

At present, the commonly used means of caries prevention include pit and fissure closure and immune caries prevention is widely popularized.

Fissure closure is a common means for preventing caries. The occlusal surface of the posterior teeth in the oral cavity is large and uneven, thus forming pits and fissures. The pit and fissure are easy to retain food residues and provide conditions for the reproduction of bacteria, so caries are prone to occur at the pit and fissure. The pit and fissure closure is the use of polymer materials to fill the pit and fissure, prevent food adhesion and curb the reproduction of bacteria, so as to achieve the effect of preventing caries [7].

Immune caries prevention is a new research direction of caries prevention. Immune caries prevention is divided into active and passive immune caries prevention. Active immune caries prevention is the vaccination of caries prevention vaccine, which makes specific reactions occur in the body of the inoculator, and thus produces corresponding antibodies. Common anti-caries vaccines include whole bacteria vaccines and subunit vaccines, but both have limitations and are difficult to be widely

used[32]. Passive immune caries prevention is the introduction of specific antibodies directly into the body, so that the human body has the ability to resist caries. Compared with active immunization, passive immunization has smaller side effects and simpler operation, so it has a wider application prospect.

4.1.2 Substances of caries prevention

Common caries prevention substances include fluoride, tea polyphenols and probiotics.

Fluoride is the most commonly used substance to prevent caries. Fluoride combines with calcium ions in teeth to form calcium fluoride, which can be used as a temporary barrier to maintain the neutral pH value of the tooth surface, thereby preventing acid damage to the enamel. At the same time, fluoride can also promote the remineralization of teeth, thus achieving the effect of preventing caries[34]. Studies have shown that a certain amount of tea polyphenols has an anti-caries effect. It prevents caries by inhibiting the physiological activity of caries bacteria and preventing bacterial aggregation and adhesion. Tea polyphenols have the advantages of easy availability of raw materials, no side effects and low cost, and have broad application prospects. Probiotics are microorganisms beneficial to the host. Probiotics in the mouth compete with cariogenic bacteria for nutritional sources and living space, thereby inhibiting the reproduction of cariogenic bacteria. Moreover, the metabolic acid production of probiotics is less than that of

cariogenic bacteria, so probiotics can prevent tooth surface from forming an acidic environment, so as to achieve the purpose of preventing caries[35].

4.2 Personal living habits

In the diet, reasonable diet, balanced nutrition; appropriate supplements of calcium, phosphorus and vitamin D can increase the hardness and toughness of teeth[5]. Refined sugar intake and frequency should also be reduced. In addition, coarse fiber food should be properly ingested to exercise children's masticatory function, and coarse fiber food can rub the tooth surface to play a cleaning role. Good oral hygiene habits can not only inhibit the growth of bacteria, but also provide a healthy growth environment for teeth, thereby reducing the incidence of caries.

4.3 Social environment

Caries has the characteristics of high incidence and symptoms from mild to severe, so the awareness of oral health care of the whole people should be enhanced. Governments can intensify interventions to promote the use of fluoride toothpaste, improve oral health education and teach brushing methods to young children in kindergartens and primary schools, and encourage the development of anti-caries products. The community can regularly carry out oral health care knowledge competitions and relevant knowledge lectures to form a national awareness of caries prevention.

5. Summary and outlook

The World Health Organization lists dental caries as one of the three major non-communicable diseases in the world, so it is necessary to study the pathogenesis and treatment of caries. At present, the pathogenesis of caries mainly focuses on the quadruple factor theory of bacteria, host, time and food. The treatment of caries is mainly divided into early, middle and late stages. The early treatment methods include drug treatment and pit and fissure sealing, while the middle and late stages mainly use filling treatment and root canal treatment. However, each treatment method has its own advantages and disadvantages, and it is necessary to select the best scheme according to the specific actual situation. In addition, the occurrence of caries is closely related to the personal habits of the host and the physical condition of the host.

Reducing the incidence of caries requires a clear understanding of the pathogenesis of caries. In the future, the pathogenic mechanism and physiological function of bacteria can be studied in depth to understand the relationship between cariogenic bacteria and the human body, and better realize the prevention of caries in principle. At the same time, we should further study the prevention policy of caries, strengthen the scientific prevention of caries, and accelerate the improvement and popularization of caries vaccine. In addition, there should be a clear and effective treatment for patients with

different stages and ages of caries, and the sustainable development of caries should be prevented in the process of treatment.

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