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Advances in the study of dental caries and systemic diseases

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Abstract: *Dental caries is a common chronic oral disease that seriously affects people's health and quality of life, while patients with systemic diseases often neglect oral health due to systemic disease conditions, leading to the occurrence of oral problems, and some systemic diseases may promote or aggravate the development of oral problems, therefore, the awareness of oral health care of patients with systemic diseases should be raised, oral hygiene should be improved and quality of life should be enhanced. In this paper, the mechanism of the link between dental caries and systemic diseases and the preventive measures of oral diseases are discussed.*

Keywords: *dental caries; systemic diseases; research progress*

Dental caries (DCC) is a chronic disease of progressive multi-factorial destruction of dental hard tissues dominated by oral microorganisms and is one of the most common diseases worldwide [1]. Patients with high sugar intake, low fluoride exposure, poor plaque control and dry mouth are at higher risk of dental caries, while patients with systemic diseases such as diabetes, Schegren's syndrome, nephrotic syndrome and cancer have a higher than normal dental caries rate due to reduced saliva flow and salivary gland lesions caused by the disease. Dental caries can cause pain and other discomfort and has a significant impact on the patient's quality of life. The indirect link between dental caries and systemic health has received little attention [2]. Therefore, patients with systemic disease and their families should pay more attention to oral health education, develop good personal oral hygiene habits and correct poor lifestyle habits such as smoking, alcohol abuse and excessive sugar intake. This article briefly summarizes the mechanism and preventive measures between dental caries and systemic diseases, aiming to provide assistance in the diagnosis and treatment of dental caries and systemic diseases.

1. Dental caries and diabetes mellitus

Diabetes mellitus (DM) is a chronic metabolic disease characterised by impaired glycaemic control, and uncontrolled diabetes can lead to many serious impairments or complications [3]. The oral cavity is one of the areas of the body affected by chronic hyperglycaemia. Oral complications in diabetic patients are due to low neutrophil function, microangiopathy, neuropathy, reduced collagen synthesis and reduced collagenase activity. A bidirectional relationship between diabetes and periodontitis has now been established [4]. There are several mechanisms that can explain the relationship between dental caries and diabetes: firstly, DM patients with poor glycaemic control are more likely to develop periodontitis, which has been shown to be associated with dental caries, and inflammation of periodontal tissue increases the amount of root exposure, thus increasing the susceptibility to root surface dental caries. Secondly, insufficient salivary flow, reduced salivary volume and changes in salivary composition are also part of the oral manifestations of DM, saliva has a protective effect against dental dental caries and salivary flow and buffering capacity are significantly altered in DM patients, thus increasing the risk of dental dental caries. Patients with DM have higher than normal glucose levels in their saliva, resulting in a lower salivary pH, which, at low pH, promotes the growth of acid-producing microorganisms, resulting in an environment conducive to dental caries development [5]. Furthermore, the colonisation of caries-causing bacteria, particularly Candida, is higher in the mouth of DM patients compared to non-diabetic patients, and current studies have shown that it is mainly Candida albicans that is associated with root surface caries [6]. Finally, patients with DM who have poor glycaemic control may lack awareness or habits to maintain good oral hygiene, people with DM may brush or floss less frequently and have fewer dental visits than non-diabetics, and people with DM rarely recognise that their oral health may be

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affected by DM, so those who do not control their sugar intake are more likely to develop dental caries than those whose blood glucose levels are well controlled [3].

Most patients with dental caries DM are not aware of the relationship between oral problems and DM, thus ignoring oral problems, which eventually lead to adverse consequences such as dental caries or even tooth loss. In order to improve the overall and oral health of DM patients, a partnership should be established between patients, doctors and dentists. Firstly, change the structure of the diet, sugar and carbohydrate intake is a common risk factor for both dental caries and DM, reducing sugar and carbohydrate intake can reduce the risk of dental caries and good control of blood sugar. Secondly, to raise and develop awareness of oral hygiene in DM patients, the use of fluoride toothpaste and fluoride mouthwash to prevent dental caries and antibacterial plaque rinse to prevent periodontal problems should be recommended. Brushing with fluoride toothpaste twice a day and flossing once a day should be emphasised to ensure plaque control. Patients are encouraged to visit their dentist regularly for routine check-ups as well as to control blood sugar levels. Prevention of harmful complications is the responsibility of dental professionals and government agencies [5, 7].

2. Dental caries and schegren's syndrome

Sjögren's syndrome (SS) is a chronic systemic autoimmune disease that progresses slowly and is characterised by a large infiltration of lymphocytes, mainly involving the salivary and lacrimal glands, resulting in dry mouth and dry eye [8]. Saliva is a complex fluid containing a variety of proteins, lipids, electrolytes, immunoglobulin A, hormones and buffers. The main functions of saliva include balancing the oral microbiota, providing lubrication and protection to the oral mucosa and tongue, facilitating the digestion of carbohydrates in the mouth, providing acid-base buffering and mineral salts, acting as a physical barrier and participating in wound healing mediated by epidermal growth factor (EGF) and vascular endothelial growth factor (VEGF), dysfunction of the salivary glands in SS patients resulting in reduced saliva production and Altered salivary chemistry including altered antimicrobial properties of saliva, reduced calcium and phosphorus concentrations that promote tooth mineralisation and integrity. Chronic low irritation whole-mouth saliva flow rates of less than 0.8 to 1 ml/min are the strongest predictor of high dental caries rates, and SS patients have reduced saliva flow rates, resulting in higher dental caries rates in SS patients compared to healthy controls. Secondly, the antibacterial activity of saliva is reduced in SS patients, leading to a high growth of bacteria in the saliva. The reduced calcium and phosphorus concentration in saliva weakens the patient's buffering capacity and remineralisation of enamel and dentin caries, all of which contribute to the higher than normal dental caries rate in the mouth of SS patients [8-10].

For the prevention of dental caries in SS patients with dry mouth, saliva stimulants, such as pilocarpine, are recommended to increase salivary secretion according to clinical practice guidelines; topical fluoride may also reduce the incidence of dental caries. Therefore, fluoride may be considered as the main therapy for the prevention of dental caries in SS patients, but it has not been supported by any other randomised clinical trials,In the meantime, patients should be made more aware of oral hygiene and maintain good oral hygiene[11]. Prevention of the development of oral disease and its sequelae is essential[6] and an interdisciplinary approach to diagnosis and treatment, with the collaboration of patients, dentists, rheumatologists, ophthalmologists, otolaryngologists and pathologists, can yield full information about the patient, allowing earlier diagnosis and treatment of SS before irreversible and devastating changes in the salivary glands and other glandular or extraglandular complications[12].

3. Dental caries and nephrotic syndrome

Nephrotic syndrome (NS) is a common chronic kidney disease in children in which the increased permeability of the glomerulus to plasma proteins causes urinary protein to exceed the body's ability to compensate (50 mg/kg/d). The incidence is reported to be higher in Asian children than in European and African children. NS is usually treated with corticosteroids [13, 14]. Proteinuria can lead to hypoproteinaemia and mineral loss with urine and glucocorticoid therapy, as well as a risk of abnormal calcium and vitamin D3 metabolism, so that children with NS have both hypocalcaemia and reduced levels of vitamin D3 metabolites. Protein deficiency may prevent the formation of a protein matrix for dental tissue and disruption of the calcium and phosphorus balance may inhibit tooth mineralisation. Tooth formation begins around the eighth week of foetal life, mineralisation of the crowns of the milk teeth begins in the fourth month of foetal life and continues until the twelfth month of the child's life, and mineralisation of the crowns of the permanent teeth begins in the perinatal period and continues until the

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seventh or even eighth year of the child's life (excluding the third molar). This means that the disruptions in calcium, phosphorus, protein and fat metabolism that occur during this period may lead to various dental and skeletal developmental abnormalities and disturbances in the metabolism and absorption of calcium, phosphorus and vitamin D. This, together with proteinuria, leads to poor enamel mineralisation, which is a common condition in children with NS [13]. Treatment of children with NS is based on glucocorticoid therapy, which is potent drugs with immunosuppressive and anti-inflammatory effects, and their long-term use may lead to a number of adverse effects. In children with NS glucocorticoid use may lead not only to infection but also to impaired development of the masticatory organs, skeletal abnormalities and soft tissue calcification [13, 15]. In addition, poor oral care, high snack intake and lack of parental supervision contribute to the deterioration of oral health in children with NS [14].

Collaboration between dentists and paediatric nephrologists is needed in the oral care of patients with nephrotic syndrome, as well as a better understanding of the interrelationship between systemic abnormalities and dental caries. The oral surgeon should also consider the side effects of medication and the appropriate medication to prescribe given the impaired renal function [15]. Parents of children with NS should also be made more aware of their children's oral health care, recognising that dental caries and serious oral problems are also risk factors for the recurrence of NS, so maintaining good oral health is also essential, so children with NS should have good oral hygiene, a change in diet and regular oral hygiene checks.

4. Dental caries and head and neck cancer

Head and neck cancer (HANC) refers to a group of malignant tumours that primarily affect the mouth, nasal cavity, sinuses, salivary glands, pharynx and larynx. Patients treated with radiation to the head and neck are prone to oral health problems. Patients with head and neck cancer after radiation treatment are at increased risk of dental caries due to radiation-induced loss of salivary gland function, radiation damage to dental structures and poor oral hygiene. Degeneration of salivary glandular alveoli and interstitial fibrosis caused by radiotherapy, stimulation of decreased whole saliva production and changes in salivary composition are the main causes of increased dental caries risk, however, changes in tooth hard tissue composition, including loss of enamel prism structure, degeneration of adult dentin cell protrusions, loss of dentin tubules and formation of gaps at the enamel-dentin junction, are also important contributing factors [16、17]. The clinical presentation of radiographic dental caries is similar to that of non-radiographic caries in patients with xerostomia, however, radiation-related caries develops more rapidly and dental caries loss is more likely to occur in non-caries-prone areas of the tooth such as the cusp and gingival margin than in typical dental caries [16]. Changes in microbial colony counts in the oral microbiota and an increase in cariogenic bacteria, including Streptococcus pyogenes and Lactobacillus, have been indicated following degrees of radiotherapy [19].

Prior to radiation therapy, spacer preparations for tooth extraction to prevent radiation osteonecrosis and to prevent severe oral mucositis; during radiation therapy, the use of a class of medications such as pilocarpine hydrochloride to stimulate saliva production under medical supervision, and patients should receive professional oral care from a dentist at least once a week until the end of radiation therapy, and it is recommended that HANC patients use a fluoride containing 5000 ppm in addition to toothpaste for brushing, in addition to using a fluoride mouthwash (0.05% sodium fluoride) at least once a day [18, 19].

5. Dental caries and atherosclerosis

Atherosclerosis is the most common chronic inflammatory disease of coronary artery disease, peripheral arterial disease and cerebrovascular disease. Chronic accumulation of subendothelial thrombotic plaques in medium and large arteries leads to narrowing of blood vessels, which restricts blood flow and ultimately leads to severe tissue hypoxia and is the most common cause of death and disability worldwide. Myocardial infarction and stroke are the most common complications of atherosclerosis [20, 21]. Epidemiological evidence supports an association between oral bacterial disease and atherosclerosis, with the oral cavity being a key pathway for bacteria to enter the body, and with the development of targeted microbial techniques, many oral dental plaque bacteria have been identified in atherosclerotic plaques, confirming the role of oral microbes in a variety of autoimmune and metabolic events such as obesity, diabetes and cardiovascular disease, with 23 species detected from atherosclerotic plaque biopsies. 23 bacteria from oral lesions have also been detected in biopsies, such as Streptococcus pyogenes, which can invade vascular endothelial and smooth muscle cells in vitro and may therefore trigger endothelial dysfunction and thus promote atherosclerosis [22, 23]. Dental caries is a chronic

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inflammatory disease of the oral cavity and oral inflammation increases the expression of many inflammatory markers and cytokines, which induces systemic inflammation and increases the inflammatory response in existing atherosclerotic lesions, thereby increasing the risk of cardiovascular disease [23]. Periodontitis has been shown to be an independent risk factor for atherosclerosis, and in a study by Bernhard Glodny et al. it was first suggested that dental caries may also be an independent risk factor for atherosclerosis to a comparable extent to periodontitis [24]. A study by Pirkko J. Pussinen et al. suggested that oral infections in children may be a risk factor for cardiovascular disease in adults. All of the above evidence suggests that oral health is closely related to cardiovascular health and therefore, oral hygiene should be emphasized and people who practice oral hygiene from an early age are at a relatively low risk of cardiovascular disease[25] . Therefore, we should enhance our awareness of oral hygiene and maintain oral hygiene.

6. Dental caries and childhood obesity

Childhood obesity is one of the most serious global public health challenges, with the average body mass index increasing in most parts of the world over the last few decades. Overweight and obese children are more likely to develop obesity in adulthood and related diseases such as diabetes, cardiovascular disease and hypertension at a young age. Obesity can also affect children's mental health and social life, such as discrimination, bullying and social exclusion, while children with dental caries can have difficulty eating and sleeping due to pain, affecting the physical health and development of the affected child [26, 27]. It is believed that dental caries and obesity share common causative factors, including genetic, socio-economic, cultural, dietary, environmental and lifestyle factors [28]. Diet is a risk factor for dental caries and obesity. Diet includes dietary habits, frequency and high intake of carbohydrates, intake of sweetened junk foods and high sugar and calorie content, and some studies have highlighted frequent and excessive intake of fermentable sugars as a key co-predisposing factor for obesity and dental caries; therefore, it is thought that changing dietary habits may be an effective intervention to reduce dental caries and obesity[27, 28] . Studies have indicated that the association between obesity and dental caries prevalence is stronger in relatively affluent areas, while in relatively poor areas the association is weak or absent. The correlation between obesity, dental caries and socioeconomic status has been a common observation[27] . It has been suggested that obesity may alter the balance of the body's internal environment, which in turn may lead to increased dental caries, and studies have shown that obese individuals have lower rates of stimulated salivary secretion, higher concentrations of secretory immunoglobulin A (SIgA), a different oral microbiota, and that obesity may also lead to changes in free salivary acid, total protein and phosphate concentrations in saliva, as well as changes in stimulated peroxidase activity in saliva. These changes can all contribute to the development of dental caries [28]. The link between obesity and dental caries may be a result of lifestyle-related factors, including short periods of exercise and prolonged use of electronic devices, and it has been suggested that obesity and increased dental caries in patients may result from unhealthy foods, low parental education and inadequate access to health care and services [28].

Oral health care for children with dental caries and obesity should still start with the basics: daily brushing, using fluoride toothpaste, improving dietary habits and lifestyles, regular oral hygiene checks, and raising parental awareness to maintain the oral and general health of the affected child [29].

7. Dental caries and inflammatory bowel disease

Inflammatory bowel disease (IBD) is a chronic immune-mediated inflammatory gastrointestinal disease. Its etiology and pathogenesis are not fully understood, but the immune system, genetics and environmental factors play an important role. the two main types of IBD are Crohn's disease (CD) and ulcerative colitis (UC). In addition to affecting the gut, oral damage, such as dental caries and periodontitis, is equally common in patients with IBD [30, 31].

Recent studies have shown that IBD is the result of an altered immune response to intestinal microorganisms. Common oral microbiota (e.g. Willettella) have been identified in the intestinal microbiota of IBD patients, and the transfer of oral microorganisms to the gut induces inflammation in IBD patients, leading to the development of IBD [31]. Patients with IBD often eat small amounts and tend to consume more refined carbohydrates and sugary foods. This is one of the reasons why patients with IBD are susceptible to dental caries [32].

Patients with IBD should be referred to a dental unit for an oral examination to check for potential

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sources of dental infection, periodontal assessment and regular follow-up (preventive dental maintenance), and prior to the use of immunosuppressive agents and biologics, it is important to eliminate sources of infection in the mouth and carry out periodontal treatment to avoid infection [30].

8. Summary

Dental caries can have a negative impact on the quality of life of the patient. Patients suffering from dental caries may resist the act of talking, laughing, smiling or kissing with others for example because of bad breath and dark teeth, thus affecting the normal social life and life of the patient. Dental caries can also lead to normal functions such as chewing and speaking, affecting the nutritional intake and daily life of the patient, and affecting the physical and mental health of the patient. Dental caries is not just a localised infection of the mouth, it can cause systemic physiopathological changes. Patients with systemic diseases are more likely to develop oral infections, and once oral infections occur, they can aggravate systemic diseases. Dental caries is treatable and preventable and further work should be done with larger sample sizes to investigate effective dental caries treatment measures to reduce the risk of systemic disease. Stomatologists should collaborate and communicate more with multidisciplinary physicians to prevent dental caries as part of systemic disease prevention in order to better protect the health of their patients.

References

[1] Mathur VP, Dhillon JK. Dental Caries: A Disease Which Needs Attention. Indian J Pediatr. 2018, 85(3): 202-206.
[2] Sabharwal A, Stellrecht E, Scannapieco FA. Associations between dental caries and systemic diseases: a scoping review. BMC Oral Health, 2021, 21(1):472.
[3] Yonekura S, Usui M, Murano S. Association between numbers of decayed teeth and HbA1c in Japanese patients with type 2 diabetes mellitus. Ups J Med Sci, 2017, 122(2):108-113.
[4] Ahmad R, Haque M. Oral Health Messiers: Diabetes Mellitus Relevance. Diabetes Metab Syndr Obes, 2021, 14:3001-3015.
[5] de Lima AKA, Amorim Dos Santos J, Stefani CM, et al. Diabetes mellitus and poor glycemic control increase the occurrence of coronal and root caries: a systematic review and meta-analysis. Clin Oral Investig, 2020, 24(11):3801-3812.
[6] Hintao J, Teanpaisan R, Chongsuvivatwong V, et al. The microbiological profiles of saliva, supragingival and subgingival plaque and dental caries in adults with and without type 2 diabetes mellitus. Oral Microbiol Immunol, 2007, 22(3):175-81.
[7] Nazir MA, AlGhamdi L, AlKadi M, et al. The burden of Diabetes, Its Oral Complications and Their Prevention and Management. Open Access Maced J Med Sci, 2018, 6(8):1545-1553.
[8] Chuang CJ, Hsu CW, Lu MC, et al. Increased risk of developing dental diseases in patients with primary Sjögren's syndrome-A secondary cohort analysis of population-based claims data. PLoS One, 2020, 15(9):e0239442.
[9] Berman N, Vivino F, Baker J, et al. Risk factors for caries development in primary Sjogren syndrome. Oral Surg Oral Med Oral Pathol Oral Radiol, 2019, 128(2):117-122.
[10] Xin W, Leung KC, Lo EC, et al. A randomized, double-blind, placebo-controlled clinical trial of fluoride varnish in preventing dental caries of Sjögren's syndrome patients. BMC Oral Health, 2016, 16(1): 102.
[11] Hsu CY, Hung KC, Lin MS,et al. The effect of pilocarpine on dental caries in patients with primary Sjögren's syndrome: a database prospective cohort study. Arthritis Res Ther, 2019, 21(1):251.
[12] Ahmadi E, Fallahi S, Alaeddini M, Hasani Tabatabaei M. Severe dental caries as the first presenting clinical feature in primary Sjögren's syndrome. Caspian J Intern Med, 2013, 4(3):731-4.
[13] Piekoszewska-Ziętek P, Olczak-Kowalczyk D, Pańczyk-Tomaszewska M, et al. Developmental Abnormalities of Teeth in Children With Nephrotic Syndrome. Int Dent J, 2022, 72(4):572-577.
[14] Luong HM, Nguyen TT, Tran HT, et al. Oro-Dental Health and Primary Nephrotic Syndrome among Vietnamese Children. Children (Basel), 2021, 8(6):494.
[15] Kaczmarek U, Wrzyszcz-Kowalczyk A, Jankowska K, et al. Oral health conditions in children with idiopathic nephrotic syndrome: a cross-sectional study. BMC Oral Health, 2020, 20(1):213.
[16] Levi LE, Lalla RV. Dental Treatment Planning for the Patient with Oral Cancer. Dent Clin North Am, 2018, 62(1):121-130.
[17] Moore C, McLister C, Cardwell C, et al. Dental caries following radiotherapy for head and neck cancer: A systematic review. Oral Oncol. 2020, 100: 104484.

ISSN 2706-6819 Vol.5, Issue 1: 88-93, DOI: 10.25236/IJFM.2023.050116

[18] Sroussi HY, Epstein JB, Bensadoun RJ,et al. Common oral complications of head and neck cancer radiation therapy: mucositis, infections, saliva change, fibrosis, sensory dysfunctions, dental caries, periodontal disease, and osteoradionecrosis. Cancer Med, 2017, 6(12):2918-2931.
[19] Kawashita Y, Soutome S, Umeda M, et al. Oral management strategies for radiotherapy of head and neck cancer. Jpn Dent Sci Rev, 2020, 56(1):62-67.
[20] Doran AC. Inflammation Resolution: Implications for Atherosclerosis. Circ Res, 2022, 130(1): 130- 148.
[21] Wolf D, Ley K. Immunity and Inflammation in Atherosclerosis. Circ Res, 2019, 124(2):315-327.
[22] Chhibber-Goel J, Singhal V, Bhowmik D, et al. Linkages between oral commensal bacteria and atherosclerotic plaques in coronary artery disease patients. NPJ Biofilms Microbiomes, 2016, 2:7.
[23] Aarabi G, Heydecke G, Seedorf U. Roles of Oral Infections in the Pathomechanism of Atherosclerosis. Int J Mol Sci, 2018, 19(7):1978.
[24] Glodny B, Nasseri P, Crismani A,et al. The occurrence of dental caries is associated with atherosclerosis. Clinics (Sao Paulo), 2013, 68(7):946-53.
[25] Pussinen PJ, Paju S, Koponen J, et al. Association of Childhood Oral Infections With Cardiovascular Risk Factors and Subclinical Atherosclerosis in Adulthood. JAMA Netw Open, 2019, 2(4): e192523.
[26] Uerlich MF, Baker SR, Day PF, et al. Common Determinants of Dental Caries and Obesity in Children: A Multi-Ethnic Nested Birth Cohort Study in the United Kingdom. Int J Environ Res Public Health. 2021, 18(23):12561.
[27] Ravaghi V, Rezaee A, Pallan M, et al. Childhood obesity and dental caries: an ecological investigation of the shape and moderators of the association. BMC Oral Health, 2020, 20(1):338.
[28] Alshihri AA, Rogers HJ, Alqahtani MA, et al. Association between Dental Caries and Obesity in Children and Young People: A Narrative Review. Int J Dent, 2019, 2019:9105759.
[29] Cheng H, Chen R, Milosevic M, et al. Interventions Targeting Bottle and Formula Feeding in the Prevention and Treatment of Early Childhood Caries, Overweight and Obesity: An Integrative Review. Int J Environ Res Public Health, 2021, 18(23):12304.
[30] Agossa K, Roman L, Gosset M, et al. Periodontal and dental health in inflammatory bowel diseases: a systematic review. Expert Rev Gastroenterol Hepatol, 2021, 1-15.
[31] Elmaghrawy K, Hussey S, Moran GP. The Oral Microbiome in Pediatric IBD: A Source of Pathobionts or Biomarkers? Front Pediatr, 2021, 8: 620254.
[32] Zhang L, Gao X, Zhou J, et al. Increased risks of dental caries and periodontal disease in Chinese patients with inflammatory bowel disease. Int Dent J, 2020, 70(3):227-236.