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Oral Health: A Window into General Health

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Abstract

Dental caries and periodontal diseases are more important to general health than previously thought. These diseases are diet related as are obesity, type 2 diabetes, cardiovascular disease, and other diseases. A similar diet seems to have a central role in all of these diseases. Since dental caries in children can be seen at an early age, it should serve as warning to all concerned practitioners as this patient ate the wrong diet for both dental and general health.

Introduction

Traditionally, there was compartmentalization of the mouth from the rest of the body and the relationship of oral diseases to systemic health was lacking. The understanding of the two major oral diseases, periodontal disease and dental caries is evolving from an etiopathologic view to our current concepts.

Historically the understanding of periodontal disease has been seen in three phases; the etiopathologic (host-parasite) era, the risk factor era and the periodontal disease-systemic disease era. The last era is seen as a two-way mechanism as periodontal disease affects the body and the body can affect periodontal disease.

Dental caries continues to develop in similar, but not as distinct fashion. The first era was and continues to be the etiopathologic era (host-parasite, now biofilm), the risk factors, including CAMBRA and diet are the next era, and now the era of dental caries as part of a diet related systemic disease that affects the body.

Interestingly, the question of how oral health was associated with general health is used as means of investigation by anthropologists, e.g. the relationship between periodontal disease, dental caries and the risk of mortality in medieval England, where they found that individuals with periodontitis and dental caries were more likely to die than their peers without such pathologies [1].

Dental Caries

Evidence suggests that risk for early childhood caries, the most common chronic infectious disease of childhood, is increased by specific eating disorders. In general dental caries has decreased (but still present) from 1988 to 2004, youths aged 2 to 5 years have increased dental caries [2].

While fluorides are effective were found in studies using meta-analysis, no significant associations in either dentitions were found with baseline caries severity, background exposures to fluorides, application features, concentration of fluoride or frequency of application [3]. The disease remains a problem that is partially diet related.

Moynihan and Petersen writing from the WHO perspective state that despite improved trends in levels of dental caries in developed countries, dental caries remains prevalent and is increasing in some developing countries undergoing nutrition transition. There is convincing evidence, collectively from human intervention studies, epidemiological studies, animal studies and experimental studies for an association between the amount and frequency of free sugars intake and dental caries. Fluoride reduces caries risk but has not eliminated dental caries [4].

They continue by stating that for countries with high consumption levels of sugar it is recommended that national health authorizes and decision makers formulate country specific and community specific goals for reducing the amount of free sugars aiming towards the recommended maximum of no more than 10% of energy intake. In addition, the frequency of consumption of foods containing free sugars should be limited to a maximum of 4 times per day [4].

A systematic review of studies in humans was conducted to update evidence on the association between the amount of sugars intake and dental caries and on the effect of restricting sugars intake to <10% and <5% energy on caries. Data sources included MEDLINE, EMBASE, Cochrane Database, Cochrane Central Register of Controlled Trials, Latin American and Caribbean Health Sciences, China National Knowledge Infrastructure, Wanfang, and South African Department of Health. The conclusion was there is evidence of moderate quality showing that caries is lower when free-sugars intake is <10% energy. With the <5% energy cut-off, a significant relationship was observed, but the evidence was judged to be of very low quality. These findings are relevant to minimizing caries risk throughout the life course [5].

Sheiham and James examined the optimum intake of sugar and found that re-evaluating the dose-response relationship between sugar and caries is a robust log-linear relationship of caries to sugar intakes from 0% to 10%E sugar. New analyses show that sugar intakes should be <3% energy to minimize the disability and cost of dental caries. A 5%E sugar intake should be considered as a maximum even with the use of fluoridated water and fluoridated toothpaste. The findings from this study indicate that current approaches to controlling dental caries are failing to prevent high levels of caries in adults in all countries and this relates to current high level of sugar intake across the globe. Thus, for multiple reasons, including obesity and diabetes prevention, we need to adopt a new and radical policy of progressive sugar reduction [6].

These same dietary behaviors are also related to systemic diseases

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seen in childhood and adulthood e.g., obesity, atherosclerosis, and cardiovascular diseases and periodontal diseases in adults.

Now it is seen that oral diseases are the most common of the chronic diseases, which also includes overweight, obesity, diabetes, cardiovascular disease and more. This review will examine these associated relationships and attempt to elucidate possible underlying common mechanism(s), which could be useful for future research.

Periodontal Diseases and General Health

Periodontal diseases represent a group of infectious inflammatory diseases, which are associated with several chronic diseases, perhaps by bacteria and/or inflammation. Periodontitis is a chronic inflammatory disease, resulting from a predominantly Gram-negative microbial infection, which is in a sub-gingival dental plaque biofilm. The resulting inflammatory response in the periodontal tissues may facilitate intravascular dissemination of micro-organisms and their products throughout the body [7].

Periodontal diseases are characterized by systemic inflammatory host response that may contribute a higher risk to general diseases would include diabetes, heart disease, stroke, osteoporosis, respiratory disease, and cancer risk [8].

Waite and Bradley in 1965 estimated that in patients with moderate to severe periodontitis and pocket depths of 6-7 mm and bone loss, the surface area of inflammation and infection ranges from 8 to 20 cm^2, in other words approximately the size of a palm of the hand or larger [9].

Thus, inflamed and infected periodontal pockets containing highly organized sub gingival Gram-negative biofilms can serve as a large reservoir from which the bloodstream is permanently flooded with bacteria, bacterial by-products, such as LPS (lip polysaccharide), and pro-inflammatory cytokines that could reach all parts of the body and affect distant sites and organs [10].

Periodontal Disease and Obesity

The population of the US has a many overweight or obese individuals that could possibly also have periodontal disease. The NHANES [11] project found that the following statistics related to diet consumption:

*More than 1 in 3 children and adolescents aged 6 to 19 are considered to be overweight

*More than 2 in 3 adults are considered to be overweight. About 1 in 3 children and adolescents aged 6 to 19 are considered to be obese.

*More than 1 in 3 adults are considered to be obese.

Thus the U.S. population has a high percentage of people who are overweight and obese with the health risks that attend this condition, which are type 2 diabetes, heart disease, high blood pressure, non-alcoholic fatty liver disease, osteoarthritis, cancers, kidney disease and stroke.

Body mass index (BMI) and obesity are associated with the prevalence, extent, and severity of periodontitis. Not only are the oral conditions in this cohort, but the non-surgical treatment responses are worse than the normal weight individual. The magnitude of this factor is in non-surgical periodontal treatment was found to be similar to that of smoking, which was also linked to a worse clinical periodontal outcome [12].

Others have also found that overweight and obesity are associated with increased periodontal disease progression [13-15].

Unfortunately this association between obesity and periodontal disease begins in adolescents. Reeves et al. [16] found that adolescents 17 to 21 had an increased risk of periodontal disease of per 1-cm increase in the waist circumference. They concluded that periodontitis may follow patterns similar to other chronic conditions that originate early in life and are related to central adiposity.

Mechanisms of Inflammation

Systemic inflammation is directly implicated in the development and exacerbation of many serious diseases, such as diabetes and cardiovascular disease [17-21].

Periodontal diseases can contribute to the total body systemic inflammation. Besides periodontal diseases, there are multiple sources of inflammation and they include: [17] an imbalance of intake of omega-6 and omega-3 fats [20], a diet high in red and processed meats, refined carbohydrates and other processed foods and diets high in saturated fatty acids [21], psychological stressors [22], cigarette smoking [23] and lack of quality sleep [23], environmental toxins [24], food sensitivities [21] and finally infection and obesity [25].

One of the more important aspects of inflammation emerged from research on the genetic determinants of inflammation, namely a specific gene variant (IL-I), which can impact both inflammatory response and clinical manifestation of a number of diseases which include coronary artery disease, Alzheimer disease, gastric ulcer and periodontitis [17,26].

Gorman, et al. [27] found that body mass index and WC-to-height ratio were significantly associated with hazards of experiencing periodontal disease progression events regardless of periodontal disease indicator.

This study allows the conjecture that poor diet can lead to overweight and obesity, perhaps resulting in systemic inflammation, and facilitating the effects of periodontal diseases microbes to produce this disease. This can more clearly noted when examining the metabolic syndrome.

Metabolic Syndrome, Periodontal Disease and Dental Caries

Metabolic syndrome is a cluster of risk factors that includes: obesity (especially the trunk), impaired glucose tolerance or diabetes, hyperinsulinemia, hypertension, and dyslipidemia [28].

At the cellular level, metabolic syndrome is characterized by oxidation stress, a condition in which the equilibrium between the production and the activiation of reactive oxygen species (ROS) becomes disrupted. ROS have an essential role in a variety of physiological systems, but under a condition of oxidative stress, they contribute to cellular dysfunction and damage. Oxidative stress may act as a common link to explain the relationship between each

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component of metabolic syndrome and periodontal disease. All those conditions show increased serum levels of products derived from oxidative antioxidant activities [28].

An increased caloric intake involves higher metabolic activity, which results in an increased production of ROS, including insulin resistance. Oxidation production can increase neutrophil adhesion and chemostaxis, thus favoring oxidative damage. Hyperglycemia and an oxidizing state promote the genesis of advanced glycation end-products, which could also be implicated in the degeneration and damage of periodontal tissues [28].

There are a number of possible mechanisms that could be responsible for increased inflammatory responses in atheromatous lesions due to periodontal infections. These include increased systemic levels of inflammatory mediators stimulated by bacteria and their products at sites distant from the oral cavity, elevated thrombotic and hemostatic markers that promote a prothrombotic state and inflammation, cross-reactive systemic antibodies that promote inflammation and interact with the atheroma, promotion of dyslipidemia and consequent increases in pro-inflammatory lipid classes and subclasses, and common genetic susceptibility factors present in both disease leading to increased inflammatory responses [29].

Metabolic Syndrome and Periodontal Diseases

Metabolic syndrome is a condition, which constitutes a group of risk factors that occur together and increase the risk for coronary artery disease, stroke and type 2 diabetes mellitus. Periodontitis has been attributed to produce a low grade systemic inflammatory condition. Metabolic syndrome and periodontitis have a common pathophysiological pathway, which were seen in systematic and meta-analysis reviews [30].

Evidence suggests that in both general population and dialysis patients that systemic inflammation plays a dominate role in the pathogenesis of myocardial infarction, stroke and sudden death. Importantly phase I periodontal therapy may decrease serum C-reactive protein levels, the most important acute phase protein, monitored as a systemic maker of inflammation and endothelial dysfunction as well, used as an initial predictor of atherosclerotic events [31].

Also states that periodontal disease can contribute to systemic inflammation. Craig et al. [32] reviewed the literature linking periodontal diseases with increased systemic inflammation and with adverse outcomes including mortality, cardiovascular events, protein-energy wasting and diabetes in end-stage renal disease patients on dialysis maintenance therapy.

Non-surgical periodontal treatment may prove beneficial in reducing rheumatoid arthritis severity as measured by ESR, CRP, TNF-a levels in serum and DAS28 in low or moderate to highly active RA patients with chronic periodontitis [33].

Numerous epidemiologic studies have associated common oral diseases, such as caries, xerostomia, periodontal diseases and edentation with the most common elements of metabolic syndrome, type 2 diabetes and cardiovascular disease. Although these associations are not well understood, various physiologic mechanisms have been proposed [34].

Obesity, a central component of metabolic syndrome, is known to interact with the inflammatory system. Since both obesity and oral health are affected by nutrition, it is plausible that the oral condition reflects the pro-inflammatory state associated with visceral obesity. Epidemiologic studies find that edentulous people have higher BMI and greater visceral obesity than the dentate [35]. Loss of teeth may promote an obesogenic diet, or this diet may promote loss of teeth [28,36].

Timonen et al. [37] studied this relationship and found that metabolic syndrome was associated with teeth with deepened periodontal pockets 4 mm deep or deeper with pockets 6 mm or deeper and with carious teeth. They concluded that metabolic syndrome or some of its components are weakly associated with periodontal infection.

Periodontal Disease and Cardiac Risk

Humphrey et al. examined studies using a meta-analysis to determine summary estimates of the risk of CHD events associated with various categories of periodontal disease. They found that periodontal disease is a risk factor or marker for coronary heart disease that is independent of traditional CHD risk factors, including socioeconomic status [38].

Blaizot et al. examined 215 epidemiological studies using MOOSE guidelines for meta-analysis and found that subjects with periodontal diseases have higher odds and higher risks of developing cardiovascular diseases [39].

Another study using meta-analysis found that periodontal disease is a risk factor or marker for CHD that is independent of traditional CHD risk factors, including socioeconomic status [40].

A joint workshop on periodontitis and systemic diseases concluded that there is consistent and strong epidemiologic evidence that periodontitis imparts increased risk for future cardiovascular disease; and while in vitro, animal and clinical studies do support the interaction and biological mechanism, intervention trials to date are not adequate to draw further conclusions [41].

Inflamed epithelium of periodontal lesions, form an easy entry point for the dissemination of bacteria, endotoxins, and other types of immune mediators that are produced locally [42].

Once in circulation, they can exert effects on distant organ systems. In addition, studies have found positive associations between periodontal disease and intima media thickness and dyslipidemia [43].

Common periodontal pathogens have been found in arterial plaques after endartectomy [28,44].

New research is reinforcing the longstanding belief that an association exists between improper oral health and CVD [45-51].

There is a large body of evidence that CVD begin early in life, persist from childhood to adolescence and results in symptomatic diseases in adult life. Interest in childhood precursors to chronic diseases is increasing because the behavioral and biological risk factors for chronic diseases persist from childhood into adulthood [45,52,53].

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Periodontal Diseases and Chronic Kidney Failure

An association between high levels of C-reactive protein and IL-6 and periodontitis has been shown. Due to this association with the systemic response, chronic periodontitis has recently been included as a non-traditional risk factor for chronic kidney failure [31].

Other epidemiological data support an association between periodontitis and chronic kidney disease [54-57].

Metabolic Syndrome, Dental Caries and Chronic Diseases

Obesity has been associated with hyposalivation [28]. The causal relationship is unknown, however, hyposalivation may trigger many oral problems, including digestion, healing of oral mucosa, maintenance of oral flora, diminished buffer capacity to protect teeth from dental decay and more [58].

There are known risk factors that make the cardiovascular system susceptible to diseases. Many of these risk factors are now brought to the life of young adolescents. Therefore, a high-risk life style from the early ages, leads to a higher risk of the heart diseases later in life. Diet, physical activity, and obesity have been highlighted among these risk factor [59]. There are also risk factors that lead to dental caries and poor oral health [45,59-61] See Figure 1.

Malnutrition (under-nutrition and over-nutrition) in children is often a consequence of inappropriate infant and childhood feeding practices and dietary behavior [62]. Some of the first clinical signs of diet imbalance that could lead to systemic diseases would be early childhood caries (ECC). Early childhood caries is a symptom of a diet imbalance, which in chronic form, can be related to systemic diseases, e.g. overweight, obesity, cardiovascular disease and cancer.

One of the common forms of sugar ingestion that leads to ECC is fructose, which is found in sugar sweetened beverages. A recent study found that children with the highest sugar sweetened beverage (SSB) intake were 2.0 to 4.6 times more likely to have severe early childhood caries compared with those with the lowest SSB. These beverages are frequently sweetened with sugar in many forms including fructose. Fructose has become ubiquitous in our food supply with the highest consumption from teens and young adults. Thus the understanding of high consumption of fructose in the role of oral and body diseases is important [63].

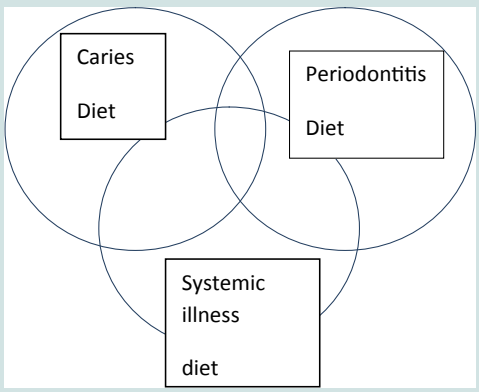

Figure 1: Dietary relationships between teeth, periodontal tissues and body that result in disease(s) show areas where dietary commonalities lead to multiple diseases.

Summary

The relationship between diet and dental caries has been known for a long time, what is now being appreciated is that the same diet over time can be associated with systemic diseases such as overweight, obesity, cardiovascular diseases, diabetes and more. Some of the diet factors in dental caries are also found in the periodontal diseases diet. These diet factors are associated with systemic inflammation and local inflammation such as found in periodontal diseases. Chronic periodontal diseases are associated with systemic diseases directly from periodontitis.

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