

Oral health and nutrition as gatekeepers to overall health: We are all in this together

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ABSTRACT

Oral diseases are prevalent worldwide and have significant health implications. Complex multidirectional relationships exist among oral health, general health, and nutrition, although the extent of these relationships is not completely understood. The purpose of this review was to examine some of the known relationships among oral health, general health, and nutrition and to provide nutrition-based recommendations for patients with common systemic and oral conditions.

Key words

Diet, nutrition, oral health

INTRODUCTION

Oral diseases are the most common of all chronic diseases and have serious and broad implications due to their prevalence, impact on individuals and society, and the costs of treatment.^[1] Oral diseases and disorders collectively affect 3.9 billion people worldwide, and the global burden of oral conditions has increased 20.8% since 1990.^[2,3] Oral health is an important determinant of overall health, and can impact and be impacted by dietary and/or nutritional factors. Therefore, all healthcare professionals need to understand the potential relationships among nutrition, oral health, and general health and adopt an interdisciplinary approach to providing optimal patient care. Since the dental professional has more frequent contact with patients than most other health professionals, early detection of disease and its risk factors may enable prompt patient referral for definitive diagnosis and treatment to improve patient health and reduce long-term healthcare costs.^[4] Indeed, since all aspects of healthcare are

interdependent, present and future practice require that health professionals work together in interdisciplinary teams for effective patient-centered care.^[5]

This paper will review the major relationships among diet/nutrition/oral health/and general health and provide meaningful nutrition messages for patient education to prevent and/or ameliorate oral problems or their effects.

RELATIONSHIPS BETWEEN ORAL AND SYSTEMIC CONDITIONS

Increasing attention and research have focused recently upon relationships between oral and overall health [Figure 1]. The oral cavity is a vehicle for the transmission of disease-causing microorganisms, as well as a portal, of entry for systemic infections. These pathogens or their cytotoxic by-products are known to cause dental caries, periodontal disease, and other local oral and pharyngeal infections. However, they can also enter the bloodstream, (directly through ulcerated tissue, diseased teeth, or periodontal tissues and/or indirectly through lymphatic channels), and potentiate an immune response elsewhere in the body or contribute in other ways to systemic disease.^[6] Conversely, chronic diseases, particularly immune compromising conditions, can worsen oral health issues by lowering the immunity needed to fight infection. For example: Diabetes complicates periodontal health and vice versa.^[7]

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Figure 1: Nutrition/oral health relationships

SYSTEMIC NUTRITION AND ORAL AND GENERAL HEALTH AND DISEASE

Good nutrition is essential for growth, development, and continued health throughout the life span, and has oral implications as well. Several of the major chronic health conditions worldwide such as cardiovascular disease (CVD), diabetes, cancer, and obesity, are strongly related to diet, particularly diets rich in saturated fats and added sugars, and low in polyunsaturated fats, fiber, Vitamins A, C, and E.^[8]

The first clinical signs and symptoms of nutritional deficiencies are usually seen in the oral tissues such as smooth tongue in pernicious anemia, oral mucositis or glossitis in Vitamin B deficiencies, or gingival swelling, bleeding, and impaired healing caused by Vitamin C deficiency.^[6] Conversely, nutrient excesses due to over-supplementation, particularly of Vitamin A, can lead to impaired healing of oral soft tissues.

Both oral and systemic problems can result in reduced appetite and changes in the ability to chew, taste, and swallow. This in turn influences food and beverage choices, and the frequency of eating occasions.^[6] For example, reduced oral functioning or tooth loss, is linked to a qualitatively poorer diet, probably because many nutritious whole foods, such as meats, fruits, beans, vegetables, and grains, may also be difficult to chew.^[6] Thus, poor oral health can be a major risk factor for poor nutrition, and ultimately impaired health in general.

In addition, many medications prescribed for the treatment of chronic diseases may cause oral complications such as xerostomia and mucositis, which may also impact the ability to eat and food choices.^[6]

DIET EFFECTS ON DENTITION THROUGH THE LIFECYCLE

Dental caries is a major global issue, with untreated caries in permanent teeth affecting approximately 35% of people all ages worldwide.^[2] Dietary habits are the initiating factor in dental caries formation. Dental caries results from the interaction of three factors: Susceptible teeth, bacterial colonies in dental plaque adhering to tooth surfaces, and simple sugars from the diet serving as the food source for the bacteria.^[9] The process of caries begins when the bacteria in dental plaque are provided with simple sugars from the diet (the mono and di-saccharides glucose, fructose, galactose, lactose, maltose, and/or sucrose) as a food source. The result is high concentrations of organic acids produced by bacterial metabolism of these sugars, which initiates the tooth enamel demineralization and begins the caries process. Most importantly, it is the amount of TIME that dietary sugars are in contact with bacterial plaque, NOT the total amount of sugars consumed, that is the critical factor in caries risk.^[9-12] Dental caries is not only a disease of children. It affects all age groups, and the etiology is the same in children as in adults and elders.^[11]

Pregnancy

Frequent vomiting or morning sickness during pregnancy may result in repeated enamel exposure to gastric acid. Furthermore, pregnant women's eating habits and cravings may lead to frequent snacking on candy or other cariogenic foods and beverages.^[13] In turn, oral discomfort or disability can interfere with the consumption of the nutrient-rich diet required for a healthy developing baby. Maternal malnutrition, in turn, is a risk factor for prematurity and low birth weight in infants.^[14] For this reason, a pregnant woman should continue to see her dental professional and should be educated on methods of caries prevention and referred to a registered dietitian for further diet advice if needed.

Childhood

Early childhood caries (ECC), defined as "the presence of 1 or more decayed (noncavitated or cavitated lesions), missing (due to caries), or filled tooth surfaces in any primary tooth in a child 71 months of age or younger," is a major public health problem in many areas of the world.^[15] Factors associated with ECC include: Low socioeconomic status, minority status, older age, high sugared snack or beverage consumption, improper bottle use, higher levels of mutans streptococci, and poor oral hygiene.^[16] In particular, study results suggest that consumption of sugar-sweetened beverages in children up to 24 months of age is a strong and identifiable predictor of ECC development.^[16] The frequent, prolonged exposure of children's teeth to sugar-sweetened beverages that is associated with ECC development typically occurs with

frequent bottle feeding at night or putting a baby to bed with a bottle, breast-feeding *ad libitum*, and extended and repetitive use of a no-spill training cup, all of which allow for the fluid to pool around the teeth and gums and feed the bacteria, resulting in decay.^[13,15,17] Dental professionals can provide education to parents to decrease the risk of ECC. Guidelines for infants include: Providing only water in bottles at naps or bedtime, controlling the amount of sugar the child consumes, reducing intake of cariogenic foods (including fruits, juices, sodas, crackers, and teething biscuits), never dipping pacifiers in fermentable carbohydrates (i.e., sugar, honey, juice), introducing the cup at 6 months of age and begin to wean from the bottle, and cleaning teeth after each feeding.^[13,17] Prior to eruption, protein-calorie malnutrition and deficiencies in Vitamin C, Vitamin A, Vitamin D, calcium, phosphorus, and iodine can lead to teeth defects such as enamel hypoplasia and hypo mineralization, which can both increase susceptibility to dental caries once teeth erupt.^[6] Thus, it is important to emphasize adequate nutrition in infancy to prevent caries predisposition. As the child becomes toddler aged, additional recommendations include limiting cariogenic foods to mealtimes, following meals with brushing, and choosing snacks with caries-protective effects, such as cheese and nuts.^[13]

Teens

As the child progresses into middle childhood and adolescence, caries risk remains a potential problem. Teens become more independent, and food and beverage choices are less influenced by parents and more influenced by peers, causing an increase in soda or sugar-sweetened beverage and sugary or starchy snack consumption. Counseling points from dental professionals to children and teenagers should include: Limiting consumption of sweets, particularly, when it comes to sugar-sweetened beverages (including sports and energy drinks), choosing sugarless gum, and opting to snack on foods between meals such as low-fat cheese, yogurt, nuts, or raw vegetables.^[17]

Adults

Since the etiology of caries is the same for all age groups, adults are also at a high of a risk for developing caries.^[11] According to the World Health Organization (WHO), most dental caries occurs in adults, even in the presence of fluoride.^[11] An extra point of concern includes excessive alcohol consumption, which can cause dehydration associated with dry mouth and reduced saliva flow, which can lead to tooth decay over time since saliva plays an important role in neutralizing plaque acids.^[11] Nutrition recommendations for caries prevention in children are also applicable to adults. Specifically, a systematic review by the WHO concluded that there may be a benefit in limiting sugar consumption to <5% of total calories to minimize the risk of dental caries throughout the life

cycle, likely due to reduced frequency and time of contact between teeth and sugar and not due to reduced volume of sugar.^[11]

Seniors

As adults age, xerostomia, a common side effect of many prescription medications, increases caries risk.^[17] For those experiencing xerostomia, recommendations should include drinking more water for oral lubrication, using sugar-free gum to stimulate saliva production, and avoiding foods and beverages that irritate dry mouths such as coffee, alcohol, carbonated soft drinks, and acidic fruit juices.^[17] If seniors experience tooth loss, they may choose more soft foods for ease of mastication. Since this often means eliminating high fiber or whole foods, this may predispose to a diet of poor nutrient quality which can lead to malnutrition.^[6]

NUTRITION AND PERIODONTAL DISEASE: A BI-DIRECTIONAL RELATIONSHIP

Inflammatory periodontal diseases are also a substantial global burden, with gingivitis and periodontitis affecting approximately 90% of the world's population.^[7] Periodontitis, the advanced form of the inflammatory periodontal disease, can lead to tooth mobility and/or loss, repeated periodontal infections, compromised physical appearance, and gingival bleeding.^[7,8] These consequences of periodontitis negatively affect the quality of life due to reduced self-esteem, mouth function, social interaction, comfort, and food choices.^[3] In adults between the ages of 35 and 59, severe periodontitis was the leading cause of oral disability, and severe tooth loss was most prevalent in adults over the age of 60 years.^[3]

A number of studies have demonstrated that periodontal disease and nutrition have a bi-directional relationship. The general role of nutrients in periodontal disease is seemingly related to conditions that lead to increases in dental plaque, impaired immunity, and reduced integrity of periodontal tissues, such as in malnutrition.^[6] Specifically, the severity of gingivitis has been associated with deficiencies in Vitamin C and folate, and increased severity of the periodontal disease has been associated with excessive alcohol consumption.^[6] In turn, periodontal disease, particularly that which results in tooth loss, causes reduced chewing ability, even when dentures are worn.^[6] This reduced oral functioning and poor dentition may result in protein-calorie malnutrition and/or deficiencies of Vitamin A, Vitamin C, Vitamin D, calcium, phosphorus, iron, and iodine, likely due to poor oral intake and decreased food choices or variety.^[6] For individuals with the periodontal disease, alterations in texture, consistency, and acidity may be necessary [Table 1] for diet recommendations and specific food examples.

Table 1: Dietary recommendations for oral complications

Oral complication	Dietary recommendations	Examples
Caries risk	Minimize between meal snacking or sipping on sweet and/or acidic beverages as much as possible Keep sweets at mealtimes and brush/floss afterward Rinse with water after each eating or drinking period, especially between meals Avoid slowly dissolving sugar items such as breath mints, hard candies	Use artificial sweeteners rather than sugar or honey Have proteins, fruits and vegetables, and dairy products such as cheese and unflavored yogurt for snacks
Chewing difficulties (due to missing teeth or oral pain)	Choose soft, smooth foods Cut food into small bites Mash or blend foods Chew slowly and thoroughly Moisten dry foods with sauce, broth, butter, or gravy Take sips of liquids while eating Cook vegetables to soften them	Pudding Yogurt Applesauce Ice cream Mashed potatoes Eggs Pureed soups Casseroles Pasta Stews Smoothies Milkshakes Ground meats with gravy Milkshakes, smoothies, or frappes Soups Nutrition supplements (Ensure, Boost, etc.) if oral intake is poor Soft fruits: Bananas, peaches, pears, and watermelon Macaroni and cheese Pudding Gelatin Oatmeal Pureed or mashed vegetables Herbs (fresh or dried) Pepper Spices Vinegars Lemon juice Garlic
Mucositis	Choose foods that require minimal chewing Avoid acidic, spicy, salty, coarse, and dry foods Blend foods that are difficult to chew Cook foods so that they become softer Cut foods into smaller pieces Use a straw to drink liquids Choose cold or room-temperature foods	Soups Nutrition supplements (Ensure, Boost, etc.) if oral intake is poor Soft fruits: Bananas, peaches, pears, and watermelon Macaroni and cheese Pudding Gelatin Oatmeal Pureed or mashed vegetables Herbs (fresh or dried) Pepper Spices Vinegars Lemon juice Garlic
Impaired taste or taste changes	Add flavor to foods Do not add extra salt for flavor Ensure adequate intake of greens and vegetables Add citrus flavors to reduce a metallic taste in mouth Zinc sulfate supplements may help recover taste in cancer therapy patients	Soups Peanut butter on bread Casseroles Gravies Sugar-free gum Fruit nectar instead of juice Mashed potatoes with gravy
Xerostomia	Avoid dry foods such as bread, crackers, or rice Drink adequate water for oral lubrication (25-30 mL/kg/day) Eat soft, moist foods that are cool or room temperature Add gravy, sauce, or butter to foods Take small sips of liquids between bites Minimize foods and beverages that may irritate dry mouth, such as coffee, acidic fruit juices, or alcohol Chew sugar-free gum or suck on sugar-free candies to stimulate saliva production	Soups Peanut butter on bread Casseroles Gravies Sugar-free gum Fruit nectar instead of juice Mashed potatoes with gravy

SYSTEMIC HEALTH ISSUES WITH NUTRITION AND ORAL ASSOCIATIONS

Recent research has further explored the relationships between oral infection, its associated tissue inflammation, and systemic diseases.^[18] This section briefly covers the relationships between various systemic diseases of increasing public health concern and oral health, along with implications for nutrition and counseling points for dental professionals.

Diabetes and periodontal disease

Currently, approximately 347 million people suffer from diabetes mellitus worldwide, with estimations of increased prevalence of 439 million people, or about 10% of all adults, by the year 2030.^[7] Recent research shows a bi-directional relationship between diabetes and periodontal disease.^[19] Epidemiological studies have consistently shown an increased risk of periodontitis in those with diabetes, with the severity of periodontitis dependent on the level of glycemic control.^[7] Some

researchers have even proposed periodontal disease to be the sixth complication of diabetes.^[20] The mechanisms by which diabetes increases the risk of periodontal disease are not completely understood, but likely include aspects of impaired immune function and increased inflammation with associated increased pro-inflammatory cytokine production.^[7,20] Aside from periodontal disease, oral manifestations of diabetes include xerostomia, oral candidiasis, glossopyrosis, impaired oral wound healing, recurrent oral infections, and acetone breath.^[19] In turn, the severity of periodontitis appears to influence glycemic control and the development of other complications in diabetics.^[21] A Cochrane review in 2010 concluded that periodontal treatment has a statistically and clinically significant beneficial effect on glycemic control in those with diabetes.^[22]

Periodontal disease is an early complication of diabetes, and many periodontal patients have unrecognized prediabetes or diabetes.^[23,24] In view of patients typically seek out preventive oral care more frequently than preventive medical care, the dental practice is an opportune location for diabetes screening, with early diagnosis and treatment helping to improve overall patient health and avoid or reduce diabetes-related complications.^[19,23] Diabetes screening in the dental practice may include identification of some level of risk based on age, race/ethnicity, overweight or obesity, central adiposity through self-reported waist circumference, and physical inactivity, followed by a periodontal examination and a point-of-care hemoglobin A1c test.^[23,25] For those with suspected prediabetes or diabetes, lifestyle interventions include losing a modest amount of weight (7% of bodyweight), increasing physical activity to at least 150 min/week, reducing calories and dietary fat to improve weight loss, limiting alcohol consumption, choosing whole grain or higher fiber carbohydrates in controlled quantities, and limiting refined carbohydrate sources.^[25] Patients should be referred to a physician for a definitive diagnosis and to a registered dietitian to receive appropriate and detailed medical nutrition therapy in order to receive proper treatment.^[25]

Cardiovascular disease

Worldwide, CVDs are the leading cause of mortality.^[26] Evidence from epidemiological studies has suggested statistically significant associations between periodontitis and CVD, with inflammation being a common factor.^[26,27] This association is hypothesized to be due to the movement of bacteria and bacterial products through ulcerated epithelium in periodontitis into the circulatory system, which causes the dissemination of inflammatory mediators that can result in vascular endothelial activation and dysfunction.^[21] Essentially, localized chronic inflammation of periodontal tissues leads to systemic inflammation that can result in dyslipidemia and atherosclerosis.^[28] This biologically plausible

hypothesis is supported by the detection of periodontal pathogens in human and animal atherosclerotic plaques and meta-analysis findings that individuals with periodontitis may have a 1.14–2.2 times greater risk of developing coronary heart disease compared to individuals without periodontitis.^[26,29]

There are a number of confounding factors that are associated with both periodontitis and CVD, including age, body mass index, socioeconomic status, gender, diabetes, psychosocial stress, and lifestyle factors such as diet, exercise, and smoking.^[27,29,30] In the dental office, modifiable lifestyle factors associated with periodontitis and CVD should be addressed, including smoking cessation, promoting a well-balanced diet along with a healthy body weight, and increasing physical activity.^[30] Those who are at high risk of CVD and have not seen a physician within the last year should be referred for a physical examination.^[30]

Obesity

The rates of obesity are increasing at epidemic proportions in both adults and children worldwide.^[31] Due to its associated morbidity, mortality, and economic burden, the prevention of obesity is a public health priority.^[31] Research has shown that periodontal disease is 3.1 and 5.3 times more likely to occur in overweight and obese individuals, respectively, than in normal healthy weight adults.^[31] This complex association between periodontal disease and obesity may be due to pro-inflammatory mediators in both adipocytes and periodontal disease, along with increased risk of type 2 diabetes and CVD, both of which have established associations with periodontal disease.^[31]

In view of its public health burden and its impact on oral health, dental professionals have an important role in the prevention and detection of obesity.^[31] Dental professionals are already credible sources for dietary counseling on caries prevention, which promotes dietary behaviors that reduce calorie and sugar laden foods and beverages.^[31,32] This patient education can easily be expanded to emphasize the importance of healthy dietary choices and the benefits of regular physical activity on both oral and systemic health.^[31] For those with weight management issues, patients can additionally be referred to other healthcare providers such as pediatricians, family physicians, and/or dietitians.^[31]

Immune compromising conditions

A final current issue of concern is immune compromising conditions, such as cancer and HIV/AIDS, which are significant health issues worldwide.^[33] Nearly, all HIV-infected individuals develop oral lesions at some point during their illness and approximately one-third of individuals diagnosed with cancer develop oral complications from treatment.^[6] Oral issues associated

with immune compromised conditions include: Mucositis, taste changes, xerostomia, and increased caries risk. Diets high in pickled vegetables, salted meat and fish, charcoal-grilled foods, alcohol, and smoking have been associated with increased oral cancer risk, while diets high in fresh fruits and vegetables have been associated with reduced risk, even accounting for smoking and alcohol use.^[6] Malnutrition is a common diagnosis in those with oropharyngeal cancers undergoing treatment since all cancer therapies (radiation, chemotherapy, or surgery) can have oral complications that compromise an individual's appetite and intake.^[6,34] Oral complications of cancer therapies can include tooth loss, caries, xerostomia, reduced salivary flow, loss of taste, painful chewing, painful swallowing, dysphagia, and mucositis.^[6,34] Dental professionals are able to assist these individuals by ensuring that oral complications are addressed and minimized. To reduce caries risk during radiation treatment, patients should be advised to avoid sugar-containing candy, gum or soda, and to avoid acidic foods, as well as tobacco products, and alcohol. The dental professional should encourage adequate nutrition during this time and may recommend zinc sulfate supplements if the patient experiences a metallic taste.^[35] If malnutrition is of concern, the cancer patient should be referred to a dietitian, especially because enteral tube feedings may be needed after surgery or during radiation to ensure adequate hydration and nutrition.^[34] For more specific dietary recommendations in oral complications [Table 1].

CONCLUSION

In summary, nutrition, oral, and systemic health interact in a complex, multidirectional manner. The relationships among these three healthcare fields continue to be discovered and strengthened through research. When causal relationships cannot always be concluded, there is a need for further research to conduct randomized, controlled trials, and explore additional disease states in relation to oral health and nutrition. Meanwhile, oral healthcare professionals need to be aware of these relationships and current research, provide appropriately targeted nutrition messages to dental patients, and work together with other health care providers in an interprofessional, collaborative manner to provide comprehensive care for all patients.

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