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Causal Relationship of Sugar and Dental Caries: A Review

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Abstract: ***Dental caries is the most common of all chronic diseases in industrial and in most lower income countries. Although the prevalence and severity of dental caries have decreased substantially in the past two decades, this largely preventable disease is still common, increases significantly with age, and remains a public health problem. Sugars are recognised as by far the most important dietary factor in the development of dental caries and there is a clear understanding of the biology of the process of enamel dissolution induced by acid fermented products of sugars by the action of bacteria. It has been accepted that sugar intake is the primary cause of dental caries with variations in the incidence and prevalence reflecting the impact of the above modifying factors, the usual caveats relating potentially to unknown causes do not apply because there is no other mechanism for inducing caries.***

Keywords: Sugar, Dental, Caries

1. Introduction

The actual risk of a certain food is modulated by many factors that are divided in food-related factors and consumer-related factors. Food-related factors involve the release of the sugars, the stickiness of the product although this may be less important at sites where food is impacted, and to a lesser extent, the type and concentration of the sugar. Consumer-related factors are the frequency of sugar consumption, the drinking and chewing habits, the chewing and swallowing efficiency, salivary flow and composition, the presence of cariogenic dental plaque and the use of fluorides. It is a common observation that with the comparable number of sugar-containing products, some people are able to manage the risk and will not develop caries, while others develop significant amounts of dental caries.[1- 3]

For most people, "Sugar" is only the common household foodstuff table sugar (sucrose). Out of the different types of sugars, only sucrose is used in the human diet. Technically the term "sugars" applies to two classifications of carbohydrates: free-form monosaccharides (simple sugars) which include the more common glucose, fructose, and galactose and disaccharides (two simple sugar molecules linked together) which include the most common sucrose, lactose, and maltose.[4- 6]

It has been widely accepted that sugar intake is the primary cause of dental caries with variations in the incidence and prevalence reflecting the impact of the above modifying factors, the usual caveats relating potentially to unknown causes do not apply because there is no other mechanism for inducing caries so the only confounding factors i.e. tooth brushing and the use of fluoride in drinking water or toothpaste serve to reduce the magnitude of the simple relationship between sugar intake changes and caries incidence.[7, 8]Hence; the present review was planned for summarizing the causal relationship of sugar and dental caries.

2. Dental Caries

Dental caries is a multifactorial disease, dynamics of which depend on various factors predominantly on the presence of fermentable sugar, host factors, presence of cariogenic microbial flora, and other associated environmental factors. In the context of dental caries, researchers have proposed numerous theories. One such theory, proposed by W.D Miller in 1881, and is accepted universally with modification, is "chemo-parasitic theory." This theory explains the combined effect of acid and acid-producing bacteria in the oral cavity. Considering this theory as the backbone, several models have been proposed to discuss the possible aetiology of dental caries such as J.L Williams concept of dental plaque-causing dental caries, Keyes and Fitzgerald model to explain the potential causal relationship of presence of specific microorganism like streptococci, lactobacilli in dental plaque and incidence of dental caries.[8-10]

3. Evidence Associating Dietary Factors with Dental Caries

Diet is considered as a risk factor for caries since ancient time, when Aristotle made an hypothesised sweet figs as the cause of caries. The relationship of diet to dental caries risk was suspected as early as the fourth century B.C., when Aristotle hypothesized that dental caries was caused by consumption of sweet figs, which stuck to the tooth. Current evidence from studies in humans and animals indeed indicates that dental caries does not develop in the absence of fermentable carbohydrates in the diet. Evidence also suggests that the cariogenic effect of fermentable carbohydrates can be amplified or attenuated by other dietary factors as well as by oral microflora and host factors (e.g., genetic susceptibility and the composition and flow of saliva). However, as a previous author points out, even after 23 centuries we know only a little more than Aristotle about the relative cariogenicity of foods.[11]

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prevalence and severity of dental caries have decreased substantially in the past two decades, this largely preventable disease is still common, increases significantly with age, and remains a public health problem. Sugars are recognised as by far the most important dietary factor in the development of dental caries and there is a clear understanding of the biology of the process of enamel dissolution induced by acid fermented products of sugars by the action of bacteria. A variety of factors modify this effect. Salivary pH, its composition, flow rate, frequency and amount of sugar intake, the individual tooth chosen for examination, time of exposure of tooth to oral cavity and fluoride usage has changed the enamel to make it more resistant to acid attack. Naturally occurring sugars are available in fruits, vegetables, grains, and dairy foods. Artificial sweetening agents are added sugars to satisfy taste and also as an energy source. Sweeteners can be grouped as "nutritive" or "nonnutritive". Nutritive sweeteners referred to as caloric and include sugars and sugar alcohols, however no energy is provided by nonnutritive sweeteners but they can sweeten with little volume. Both sugar alcohols and nonnutritive sweeteners can replace the sugars and are sometimes referred to as sugar substitutes, sugar replacers, or alternative sweeteners.[12]

4. Cariogenicity of Different Sugars

Sucrose for years was considered as the "arch criminal" of dental caries because of its high cariogenicity than other sugars. However, later researches showed that the differences between sucrose and the various monosaccharides in terms of cariogenic potential is not much than was originally believed. It is very cumbersome to study its effect in humans as their diet is largely variable, so views are based principally on extrapolations from animal studies and laboratory research. A study in Sweden on preschool children concluded that those consuming invert sugar (a mixture of glucose and fructose) in place of sucrose had a lower caries increment in 2 years, although the results were non significant. However, one could speculate whether reduced consumption of sucrose in the developed countries has been a factor in the sharp reduction in approximal and smooth surface caries relative to the overall caries decline. This speculation is based on the fact that the production of extracellular polysaccharides in plaque depends on sucrose and that smooth surface caries will only develop with plaque that adheres by means of extracellular polysaccharides.[13]

Sugars are readily metabolized by bacteria involved in dental biofilm formation that generates acidic by products leading to demineralization of the tooth structure. Animal studies had concluded that, Lactose (milk sugar) has been shown to be less acidogenic and cariogenic than other sugars. Due to the unique property of yielding extra cellular polysaccharides (water-soluble and water-insoluble) glucans, by action of mutans streptococci, sucrose is considered as a main cariogenic substrate. Some animal studies on rats superinfected with Streptococcus miutans also reported for increased cariogenicity of sucrose; however, this effect is not consistent across different animal models and appears to be bacterial strain-specific. Recent studies indicated that the caries-associated virulence of glucan may have more to do with an alteration in plaque ecology by increasing the porosity of plaque, permitting deeper penetration of dietary sugars and greater acid production adjacent to the tooth surface.[14]

5. Relationship between sugars and caries

Sugars plays a dynamic role with oral health. The enzyme salivary amylase hydrolyses the sugars and thus provide substrate for the bacterial action that further leads to drop in the pH of plaque and saliva. Thus results in tooth demineralization. Consumed sugars are naturally occurring or are added. Since etiology of caries is multifactorial, form of sugar whether soli or liquid or sticky, the duration of exposure, frequency of consumption, nutrient composition, salivary flow, presence of buffers, sequence of eating, and oral hygiene etc. Many studies showed a positive correlation of frequency intake of cariogenic diet with respect to dental caries.[15-20] Also Shweta et al reported a significant association between reduction in caries status and regularity of meals, decreased in between meal snacking, and consumption of food items which are less or non-cariogenic.[21] WHO recommends that the consumption of free sugars should be less than 10% for the prevention from chronic diseases like dental caries throughout life course.[22] Paula Moynihan stated that dental decay was less likely to occur when the sugar consumption was <5% of the total energy in comparison to the sugar consumption between 5% to 10 % of the total energy.[23] Not only the frequency and amount, but the form of sugar in which it is consumed plays a vital role in incidence of dental caries. Many studies concluded that more retentive forms had higher risk of dental caries.[24, 25]

With the advent of fluoride and its wider use, the incidence of caries worldwide has decreased, despite increases in sugars consumption.[26, 27] The possible biological mechanism behind this is that fluoride gets incorporated into the dental tissues and forms fluoroapatite crystals in place of hydroxyapatite crystals, which have lesser solubility, thereby making the tooth more resistant to dental caries. Other dietary factors (eg, the presence of buffers in dairy products; the use of sugarless chewing gum, particularly gum containing xylitol; and the consumption of sugars as part of meals rather than between meals) may reduce the risk of caries. The primary public health measures for reducing caries risk, from a nutrition perspective, are the consumption of a balanced diet and adherence to dietary guidelines and the dietary reference intakes; from a dental perspective, the primary public health measures are the use of topical fluorides and consumption of fluoridated water.[28]

Thus, etiological factors are broadly categorized as, 'demineralizing / pathological factors' and 'remineralizing / protective factors.' Demineralizing factors are enlisted below:

a) Fermentable sucrose-containing diet
b) Cariogenic biofilm with *S. mutans* and lactobacilli
c) Acidic by products
d) Low salivary flow
e) Low buffering capacity of both saliva and the biofilm fluid
f) Reduced oral clearance rate
g) Inadequate mineral content of the saliva and the biofilm[29]

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Sugar sweetened beverages are a major contributor to dental caries. Future intervention research should account for relevant sociodemographic, behavioral, and social determinants of added sugar intake, which will enable the field to develop and refine evidence-based strategies to prevent dental caries. Dental health professionals are in a position to implement clinical strategies that can help to reduce added sugar intake in patients and should advocate for broader policy-based solutions.[30]

6. Conclusion

Although sugar is associated with the dental diseases like dental caries, we emphasize the fact that sugar alone is not the sole determinant of these diseases. To prevent dental diseases, oral health care workers should persuade their patients to adopt special dietary programs and educate patients and motivate them to alter their customary dietary behavior.

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