Lect 15

Diet and dental caries

One of the many factors that contribute to the development of dental caries is diet that plays an important role. In conjunction with oral hygiene and other measures such as widespread use of fluoride, dietary control makes an important contribution to the multifaceted strategy for caries control.

The role diet and nutrition in the etiology and pathogenesis of caries may be viewed as systemic and local effect. In general, the term diet refers to food and drink consumption (*diaita* 'way of life') while nutrition refers to a process by which living organisms physiologically absorb and metabolize food to ensure growth, energy production, repair of tissue and ultimately reproduction of the species (*nutritio* 'to nourish')

Role of carbohydrates in caries development

It has been firmly established that dietary carbohydrate are caries conducive and they exert their cariogenic effect locally on tooth surface by influence the quality and quantity of dental plaque. Dental caries occurs as plaque bacteria metabolize fermentable carbohydrate, producing organic acids. These acids diffuse through the plaque into the enamel and dissolve mineral. If mineral diffuses out of the tooth and into the oral environment, then demineralization occurs. If the process is reversed the damaged crystal are rebuilt (remineralization).

Caries occurs when demineralization exceeds remineralization

Fermentable carbohydrate: any carbohydrate that can be hydrolyzed by salivary amylase and subsequently fermented by bacteria

Carbohydrate is an essential nutrient and can be classified in to **three** main categories:

1- Free-form monosaccharide (simple sugars) include ***glucose*** and ***fructose*** which are found naturally in fruit, vegetables and honey while ***galactose*** occur only as a result of the breakdown during digestion of lactose.

2-Disaccharides (two simple sugar molecules linked together): the most common:

- **Sucrose** (refined from sugar cane or sugar beets, it's a major part of dietary sugar) formed when one molecules of glucose combine with one molecules of fructose.
- **Lactose** is formed when a molecule of glucose combine in a molecules of galactose (milk sugar).
- **Maltose** is formed when two molecules of glucose combine; it is mainly derived from hydrolysis of the starch.

3-Polysaccharides unlike the mono and disaccharide the polysaccharides not sugar. All polysaccharides are made up of many individual sugar molecules, usually glucose, joined together. The digestible form**s** include ***starch***, which is found in rice, potatoes, peas; about half of dietary carbohydrates are composed of starch.

The fact that dental caries occur beneath dental plaque is now quite clear and this distinguish it from dental erosion that is dissolution of enamel caused by acids of non-bacterial origin.

Types of study providing evidence for the relationship between diet and caries development*:* The evidence come from a number of type of studies, these include:

- ***Observational (epidemiological) studies***: Numerous world-wide epidemiological studies show that caries prevalence is low in population adhering to a primitive way of living and a diet of local products with little sugar.
- ***Interventional studies*** : in which diets of groups of people are purposefully altered and the effect of this intervention observed. Those that have been reported are now decades old and were conducted on highly selected groups of people, before the strong link between sugars and caries was established. Such studies would not be possible to repeat today because of ***ethical constraints*** they include.

The Hopewood House was an orphanage in Australia. From its beginning sugar and other refined carbohydrate were excluded from the children diet Dental surveys of these children from the ages of 5-11 years revealed a greatly reduced caries incidence compared the state school population in that age group When the children became old enough to earn wages in the outside economy, they deviated from the original diet. A steep increase of decayed missing and filled teeth (DMFT) after the age of 11 years indicates that the teeth did not acquire any permanent resistance to caries

The Vipeholm study was conducted shortly after the Second World War in an adult mental institution in Sweden between 1945-1953. The study investigated the effect of consuming sugary foods of varying stickiness (i.e different oral retention times) and at different time through out the day on the development of caries by measuring caries increment in subjects

Main conclusions of the Vipeholm study:

- Sugar intake, even when consumed in large amounts , had little effect on caries increment if it was ingested up to a maximum of four times a day at mealtimes only
- Consumption of sugar in between meals was associated with a marked increase in dental caries
- The increase in dental caries activity disappear on withdrawal of sugar- rich foods
- Dental caries experience showed wide individual variation

- ***Animal studies***: various animal experiments were conducted to evaluate the effect of sugar intake
- ***Enamel slab experiments***: These observe the effects of diet on dmineralization in slabs of enamel (cut from extracted teeth) which are held in the mouth of human volunteers in a removable plate constructed like an orthodontic appliance.
- ***Plaque pH studies***: This type of experiment investigates the effect of food, meals, or component of foods on the pH of dental plaque. These studies are relatively easy to do, but they measure acidogenicity of diet rather than cariogenicity (only an indication of the possible effect of diet on the development of dental caries).
- ***Incubation studies***: these are the simplest but weakest method. Test foods are incubated with plaque or saliva (which contains plaque organisms) and the rate of acid production is recorded. In some experiments, whole enamel, powdered enamel, or calcium phosphate are added to the saliva/substrate mixture and the rate of dissolution of mineral is taken as a measure of cariogenic potential.

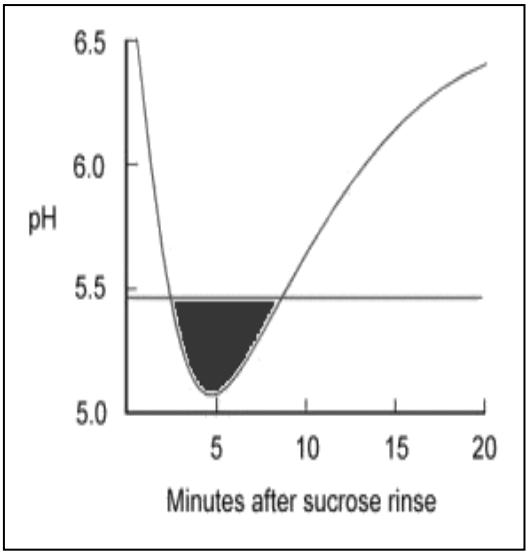
The basic Stephan curve

The resting PH of dental plaque was mostly between pH 6.5 and 7, the term ***resting plaque*** refers to plaque 2-2.5 hours after the last intake of carbohydrate. But when the plaque exposed to sucrose or glucose the pH of plaque falls rapidly below the critical value within 2-5 minutes.

(the value of pH 5.5 has become accepted as critical pH below which dental enamel will begin to dissolve because the environment is no longer saturated with enamel mineral), this rapid fall was then followed by slow recovery over the next 30-60minutes.The plot of plaque pH against time has become known as the **Stephan curve**.

The rapidity with which the pH falls is a reflection of speed on which sucrose come diffuse in to plaque and the activity of the concentration of enzymes produced by the great number of bacteria in the plaque. The slow rate of recovery to the resting pH, critical factor in caries production depend mainly on

- **Rapid production of high concentration of acids within the plaque , temporarily overcomes local buffering**
- **Escape of acids in to saliva, delayed by the diffusion-limiting properties of plaque and its thickness**
- **Diffusion of salivary buffers in to plaque hampered by the diffusion-limiting properties of plaque and its thickness**
- **Continued sugar production from bacterial intracellular polysaccharides**



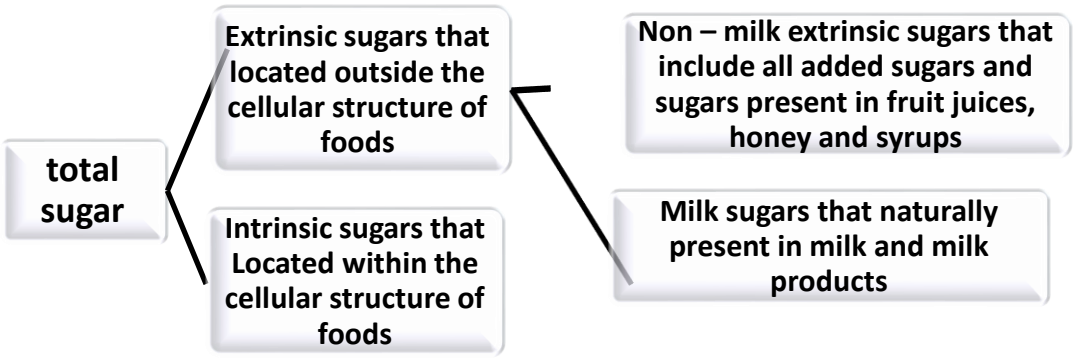
➡ Lack of saliva means long and deep Stephan curve, lengthening the time of demineralization and reducing the time when remineralization can occur.

➡ Caries free subjects tend to have a slightly higher resting plaque pH, a higher minimum pH following consumption of fermentable carbohydrate and a faster return to resting levels, when compared with caries susceptible subjects (as shown in figure above).

Factors affecting food cariogenicity:

1-Types of carbohydrates

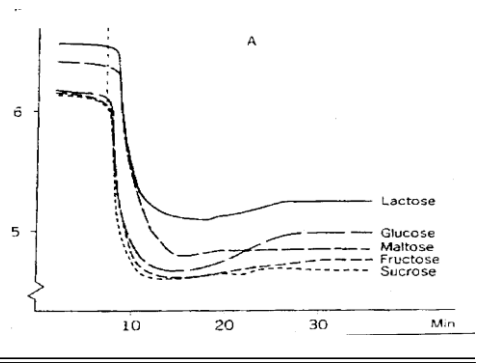
For dental health purpose , there is no evidence from epidemiological studies that sugar located within the cellular structure of a food are harmful to teeth, and therefore it is important to distinguish between theses and sugars in free form, therefore they classified sugars for dental health purpose into intrinsic and extrinsic sugars, extrinsic sugar were subdivided into milk sugars (as lactose naturally present in milk is not thought to be harmful to the teeth) and non milk extrinsic sugar which include all added sugars and sugars present in fruit juices, hony and syrups. In term of dental caries, it's the intake of non milk extrinsic sugar (or free sugars) that need to be reduced.



Sucrose is the most abundant sugar. It is used by food manufacturers all over the world as a food ingredient.

For several reasons sucrose has been called the *arch-criminal* in dental caries. The epidemiological evidence for sucrose as the cause of dental caries:

- **Low caries prevalence in population with low sucrose intake**
- **The decline in caries prevalence during wartime sucrose shortages**
- **The rise of caries prevalence with increasing availability of sucrose**
- **Archaeological evidence of low caries prevalence in eras before sucrose became freely available**
- **Low caries prevalence in disorders of sucrose metabolism hereditary fructose intolerance**



There seems to be little difference in the cariogenicity of glucose, fructose, and maltose, but the same source of evidence show that lactose is less cariogenic

Sucrose is unique because it is a substrate for extracellular dextrin synthesis by *S. mutans*. The cariogenicity of plaque depend on its ability

- ✓ to adhere to the teeth,
- ✓ to resist dissolution by saliva and
- ✓ its protection of bacterial acids from salivary buffering.

These properties depend on the formation of insoluble polysaccharides produced particularly by cariogenic strains of S. mutans. In addition, colonization by S. mutans (cariogenic bacteria) is highly dependent on the sucrose content of the diet

In the absence of sucrose, S. mutans cannot colonize the mouth, therefore its plaque counts appear to depend on the sucrose content of the diet. Sever reduction in the dietary sucrose cause S. mutans to decline in number or disappear from plaque.

Nevertheless, no sugar has been shown to be more cariogenic than sucrose and, it is the most widely available dietary sugar, it is has been subject of the greatest criticism.

Starch constitutes a heterogeneous food group, it may be highly refined or consumed in its natural state, it may be consumed raw or in cooked form- all these factors should be considered when assessing the cariogenicity of starches. They argue that all carbohydrate including starch cause dental caries, because although the starch (polysaccharide) molecules are, too large to diffuse into the plaque, however they are broken down by salivary amylase releasing ***maltose, maltotriose, and glucose*** that may be metabolized by oral bacteria to produce acids that cause dental caries.

Plaque pH drop very little following consumption of raw starch but soluble starch and starch containing food such as bread cause a pH fall which is somewhat smaller than with sugar

The starch granules of plants are only slowly attacked by salivary amylase, because the starch is in an insoluble form and protected by cellulose membrane, therefore the cariogenicity of uncooked starch is very low. Heating at temperature used in cooking cause a partial degradation to a soluble form, which can be further broken down by salivary and bacterial amylases to ***maltose, maltotriose, and glucose***.

Mixture of starch and sucrose cause a more dental caries than starch alone and the amount of dental caries was positively related to the amount of sugar in the mixture probably due to prolonged retention.

2-Physical form of food and clearance time:

In addition to the chemical composition of food, physical and organoleptic properties (particle size, solubility, adhesiveness, texture and test) are important for cariogenicity, since they influence eating pattern and oral retention of the foods. Diets that results in the greater retention of refined carbohydrate over the longest period are the most cariogenic.

- The carbohydrate in various drink are eliminated within 5 minutes while sweet such as sugar containing chewing gum, toffees, lozenges generally give high oral sucrose concentration and clearance time from 40 minutes for chewing gum to 15-20 minutes for other sweets.
- The texture of the diet is also important, for both salivary secretion and elimination of fermentable carbohydrate from the oral cavity. A diet that require thorough chewing will result in the secretion of large amount of saliva with a high pH and strong buffering capacity, in contrast to a finely textured diet that require little mastication tends to be retained in the oral cavity and eliminated slowly

The caries producing potential could possibly be reduced by modifying their physical properties (roughage, adhesiveness, solubility).

➡ Practical way to speed up carbohydrate clearance are

- ✓ tooth brushing immediately after meal, *or*
- ✓ induction of rapid salivary flow by mechanical or gustatory stimuli through eating tough or highly flavored foods at the end of meals

Chewing sugar free chewing gum or peanuts immediately after eating sugar also speed up sugar clearance and neutralization of plaque acid through saliva stimulation

Mouth rinsing with water has a very limited effect, partly because it is generally done too late: two minutes after a sucrose challenge, the sugar concentration in saliva is usually lower than that in plaque so rinsing with water at that time would not be expected to reduce the diffusion of sugar into plaque, unless the sugar clearance were excessively slow, as in xerostomic subjects.
The advantages of mouth rinsing after meal is that it also help to remove sugars in solution and food debris.

Chewing sugar-cane yield a less pronounced pH drop and a quicker pH recovery in dental plaque than is seen following a mouth rinse with sucrose. The difference probably result from stimulation of salivary flow associated with the chewing

It's often advised to consume sugar- rich foods at meal times rather than alone, or in between meals; this is because, when consumed with other foods the effect on pH is minimized probably due to
(1) The dilution effect
(2) The increased salivary flow rate due to mastication of other foods.

Frequency of intake sugar and dental caries

The relative importance of frequency versus the total amount of fermentable carbohydrate consumption is difficult to evaluate. Most studies point to the frequency of eating as being of greater etiological importance for caries than the total consumption of sugar. Frequent intake sugars will induce a prolonged and intense acid attack on the tooth surface; moreover, the time available for remineralization is thus decreased.

The pH of dental plaque falls rapidly when sugar are eaten, the more occasion sugar is taken the greater the number of times plaque pH will fall below a level where demineralization can occur (critical pH), the less time there is for remineralization to occur. With a more frequent intake of refined carbohydrate, damage time is increased and tooth repair time (remineralization) decreased proportionately.