Nutritional Aspects of Dental Caries:
 Causes, Prevention, and Treatment

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Learning Outcomes

• Explain the role each of the following play in the caries process: tooth, saliva, food, and plaque biofilm.
• Identify foods that stimulate salivary flow
• Suggest food and beverage choices and their timing to reduce the cariogenicity of a patient’s diet
• Describe characteristics of foods having noncariogenic or cariostatic properties
Introduction

• Diet and nutrients play a role in dental caries. Some foods exert a cariogenic effect, whereas others are cariostatic or anticariogenic and offer protection to reduce caries.
• The primary oral health goals of Healthy People 2020 are to:
  - reduce the number of caries in children and adolescents by 10%,
  - reduce untreated decay in this population group and adults by 10%.
• Thirty-three percent of preschool-age children and more than 50% of children and adolescents have experienced decay.
• Regarding untreated decay, 24% of preschool-age children, 29% of children, 17% of adolescents, and 28% of adults up to age 44 years have at least one untreated area.
Major Factors in the Dental Caries Process

Major actors that interact in the dental caries process
Tooth Structure

• Increasing resistance of the tooth against demineralization begins in the preeruptive phase.
• It is essential to maintain an adequate intake of nutrients during growth and development of enamel and dentin.
Tooth Structure

• The most influential nutrients include
  - calcium;
  - phosphorus;
  - vitamins A, C, and D;
  - fluoride;
  - protein.

• Indirectly, some fermentable carbohydrates play a role in the formation of caries before tooth eruption.
• Consider a child who snacks on cookies, candy, or ice cream throughout the day and is not hungry or meat, vegetables, fruit, and milk offered at mealtime.
• A child’s diet high in low-nutrient (or calorie-dense) carbohydrates may be deficient in required nutrients for optimal growth and development of the dentition.
• Overlapping and crowding of teeth
Host Factors

- Food selection
- Dietary patterns
- Oral hygiene habits
- Genetics
- Race or ethnicity
- Age
- Income
Saliva

- Availability of essential nutrients during the development of salivary glands, which begins during the fourth week in utero, has a significant impact on the amount of saliva and its composition.
Saliva

• Saliva provides protection against caries
  - Saliva acts as a buffer by neutralizing much of the acid produced by plaque biofilm as a result of carbohydrate metabolism
Saliva

• Saliva provides protection against caries
  - Normal saliva contains bicarbonate, phosphate, and protein, which dilute and neutralize acids to maintain a neutral oral pH, which is around 7.
    • After an acidic drink is consumed, the pH of the oral cavity is rapidly normalized by the components of saliva.
    • Because saliva is saturated with calcium, phosphate, and fluoride ions, the potential for remineralization (restoration of damaged enamel) and resistance to enamel dissolution exists.
Saliva

- An adequate salivary flow
  - enables rapid transport of foods from the mouth
    - decreasing the length of time harmful bacteria and food particles are able to attach to teeth and cause caries to develop

- Antimicrobial elements in saliva
  - immunoglobulin A
    - either interfere with adherence of bacteria or compete with bacteria to attach to the tooth surface.
  - An alkaline saliva offers protection, whereas an acidic saliva increases susceptibility to caries.
Plaque Biofilm and Its Bacterial Components

Bacteria
Polysaccharides
Plaque
Proteins
Lipids
Plaque Biofilm and Its Bacterial Components

Plaque biofilm forms a local barrier on enamel and may interfere with demineralization.
Ingestion metabolism by salivary amylase begins within 2 to 3 minutes and can persist for hours.

acetic, butyric, ormic, lactic, and propionic acids
Carbonhydrates

Ingestion starts

metabolic product

its metabolism by salivary amylase begins within 2 to 3 minutes and can persist or hours

Concentration of the acids escalates as carbohydrate intake continues, whereas the pH of the plaque decreases

acetic, butyric, formic, lactic, and propionic acids

Demineralization of enamel occurs when the "critical pH" of 5.5 is reached
Keynotes
Cariogenic Foods

• The average daily consumption from added sugars among 2- to 18-year olds is 365 kcals (over 90 g, or approximately 23 tsp*)

• The major sources of added sugars, in descending order, are
  - sugar-sweetened beverages (e.g., sodas or fruit drinks),
  - grain desserts (e.g., cookies or cakes),
  - dairy desserts (e.g., ice cream),
  - candy, and cold cereals

*Tea spoon, 1 tsp=16 kcals
Rethink Your Drink.

How Much Sugar Is In Your Drink?

0g  2.2g  27.5g  30g  35g  43.6g  46g
A Day of Beverages
1370 Calories
Cariogenic Foods

• Nondiet sports and energy drinks
  - fast growing sugar-sweetened beverage choices.
  - Almost 1 in 4 U.S. adults consumes sports and energy drinks at least one time per week.
  - A 20-oz* bottle of a regular sports drink contains 32 g of added sugars, a 12-oz can of energy drink contains 37 g, and 12 oz sugar-sweetened soda may contain as much as 40 g sugar

*1 oz = 29,5735296875 ml
*1 oz = 29,573,529,687.5 ml
Cariogenic Foods

- Monosaccharides and Disaccharides
  - Sucrose, fructose, glucose, and maltose
  - Small sized sugar molecules
  - Allows salivary amylase to split the molecules into components that can be easily metabolized by plaque bacteria.
Cariogenic Foods

• Sucrose
  - used to produce glucans
  - facilitating the adherence of bacteria, such as S. mutans, to the dental pellicle.

• Glucose and other carbohydrates
  - used to produce extracellular polysaccharides.

Diets containing sucrose, glucose, and other disaccharides can increase plaque biofilm mass and facilitate its retention and colonization.
Several unique properties prevent starch from providing a readily available energy source for cariogenic microflora, and it is less likely to produce caries than mono- or disaccharides

less damaging to enamel

Polysaccharides (Starches)

make it almost insoluble

the time a starch is in the mouth is usually not long enough or it to be completely metabolized if oral self-care is promptly completed
Cariogenic Foods

- Fresh fruit
  - low cariogenicity
    - its low percentage of carbohydrate and high percentage of water
  - Firm fruits such as apples
    - play a protective role by stimulating saliva flow
  - The high concentration of fructose found in juices
    - potentially a source of substrate or plaque bacteria that may influence caries risk
  - Dried fruit (e.g., raisins)
    - Sticky nature
    - increases risk of decay.
<table>
<thead>
<tr>
<th>Foods That Can Cause the pH of Human Interproximal Plaque to Fall Below 5.5</th>
</tr>
</thead>
</table>
| **Alcohol**  
• Bananas  
• Beans, baked  
• Bread  
• Candy  
• Cereals, non- presweetened, ready-to-eat  
• Cereals, presweetened, ready-to-eat  
• Chips  
• Cookies  
• Crackers  
• Doughnuts, plain  
• Energy drinks  
• Flavored coffees and teas | **Fruit, dried**  
• Fruit drinks  
• Fruit smoothies  
• Honey  
• Ice cream  
• Jams and jellies  
• Marshmallows  
• Oatmeal, instant cooked  
• Pasta  
• Peanut butter  
• Pretzels  
• Rice, cooked  
• Snack cakes  
• Soft drinks  
• Sports drinks |
Anticariogenic Properties of Food

• Some food components can protect teeth by decreasing demineralization, enhancing remineralization, or increasing salivary flow, even in the presence of a fermentable carbohydrate
Anticariogenic Properties of Food

• Sugar Alcohols
  - mannitol and sorbitol
    • substitute sweeteners
    • viable alternatives to sugar because of their sweet taste but have the added benefit of being noncariogenic
    • fermented more slowly in the mouth than monosaccharides and disaccharides; buffering effects of saliva competently neutralize destructive acids produced by plaque bacteria.
Anticariogenic Properties of Food

• **Sugar Alcohols**
  - xylitol
    - found naturally in plants
    - equal to or sweeter than sucrose.
    - classified as anticariogenic
    - oral flora do not contain enzymes to ferment it, and metabolizing microorganisms, such as S. mutans, are inhibited
    - Chewing gums, mints, and candies containing xylitol
    - inhibit enamel demineralization.
    - inhibitory effect is enhanced by
      - increased salivary flow,
      - increased oral clearance
      - greater buffering capabilities.
Anticariogenic Properties of Food

• Nonnutritive Sweeteners
  - Aspartame, saccharin, sucralose, neotame, and acesulfame
  - are not metabolized by microorganisms
  - do not promote dental caries.
  - Foods made from these sweeteners are generally higher in cost
    • not be feasible or low-income patients.
Products containing aspartame

- The following are well-known products:
  - Diet sodas
  - Yogurts
  - Chewing gum
  - Cooking sauces
  - Crisps
  - Tabletop sweeteners
  - Drink powders
  - Flavored water
  - Sugar-free products
  - Cereals

- Learn more:
  [http://www.naturalnews.com/031451.html#ixzz24SaYMX](http://www.naturalnews.com/031451.html#ixzz24SaYMX)
Anticariogenic Properties of Food

- Protein and Fat
  - they do not lower plaque pH.
  - Generally, protein may contribute to buffering effects of saliva.
  - Consuming foods with fat and protein following a fermentable carbohydrate may increase plaque pH.
  - Meat, sea food, poultry, eggs, nuts, seeds, margarine, and oils are example
Other Factors Influencing Cariogenicity

- Retentiveness of the carbohydrate
- How often or how long teeth are exposed
- Sequence in which a carbohydrate is consumed
- Whether food is eaten with a meal or as a snack.
- Some foods thought to have low cariogenic potential (e.g., corn flakes, crackers, or potato chips) may be more acidogenic than simple carbohydrate foods because of their retentiveness in embrasures, pits, and fissures.
Physical Form

• How quickly a cariogenic food is cleared from the mouth is a factor related to caries development.
• Ingestion of hard candy results in prolonged exposure.
• A sticky and retentive carbohydrate (e.g., chewy fruit snacks) remains in contact with the enamel surface or a longer period than sweetened fluids.
• Slow oral clearance of fermentable carbohydrate means longer exposure of the tooth to acid attack.
Frequency of Intake
Frequency of Intake

• Two individuals can eat equal amounts of fermentable carbohydrates, but the one who eats more frequently throughout the day has the greatest potential for decay.

• With each exposure, a decrease in pH begins within 2 to 3 minutes; at a pH of 5.5 or less (the critical pH), enamel decalcification occurs. Within 40 minutes, the pH has increased to its initial value.
A Healthy Stephan Curve

- breakfast
- snack
- lunch
- snack
- dinner

pH in Mouth

Critical pH at which teeth start dissolving

AM

Midday

PM

Danger Zone

Safe Zone
Frequency of Intake

• If a person eats a candy bar within a **5-minute** period, the teeth would be exposed to a critical pH that lasts or approximately **40 minutes** before the pH returns to the original level.

• If another person eats the same candy bar in five bites, but only takes a bite every hour until it is gone, the total acid exposure would be approximately **200 minutes**
  - (5 bites × 40 minutes = 200 minutes of acid exposure).
Frequency of Intake

- Soft drinks, sports drinks, energy drinks, and favored coffees and teas
  - The pH of diet and regular soft drinks, bottled iced teas, and sports drinks ranges from 2.5 to 3.5
  - Fruit juice should be limited to
    - 4 to 6 oz per day for children 1 to 6 years old
    - 8 to 12 oz per day or children 7 to 18 years old

*1 oz = 29.5735296875 ml
Timing and Sequence in a Meal

- The Vipeholm study
  - conducted shortly after the Second World War in an adult mental institution in Sweden between 1945 and 1953
The Vipeholm study

- The study investigated the effects of consuming sugary foods of **varying stickiness** (i.e. different oral retention times) and **at different times** through-out the day on the development of caries by measuring caries increment in subjects who consumed
  - (1) refined sugars with a slight tendency to be retained in the mouth at meal times only (e.g. sucrose solution, chocolate)
  - (2) refined sugars with a strong tendency to be retained in the mouth at meal times only (e.g. sweetened bread)
  - (3) refined sugars with a strong tendency to be retained in the mouth, in between meals (e.g. toffee)
# The Vipeholm study

<table>
<thead>
<tr>
<th>Group</th>
<th>Males (n)</th>
<th>Females (n)</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (low sugar diet)</td>
<td>60</td>
<td></td>
<td>Caries increment almost nil. Increase in sugar in second carbohydrate period was accompanied by a small but significant increase in caries.</td>
</tr>
<tr>
<td>Sucrose at meals 300 g/d reduced to ~150 g in second period</td>
<td>57</td>
<td></td>
<td>No significant increases in dental caries increment. Though slightly higher than in 1946.</td>
</tr>
<tr>
<td>Sweet bread at meals 345 g at afternoon coffee in period 1 and then at 4 mealtimes in period 2</td>
<td>41</td>
<td>42</td>
<td>Significant increase in caries increment in second carbohydrate period—significant for males only.</td>
</tr>
<tr>
<td>Chocolate 300 g sucrose at meals in first period. Then 110 g at meals and 64 g chocolate (30 g sugar) in four portions between meals</td>
<td>47</td>
<td></td>
<td>Caries increment was low in first carbohydrate period but increased significantly in the second period. In subjects aged &lt;30 there was a three fold increase in caries.</td>
</tr>
<tr>
<td>Caramel Stale sugar rich bread during first year of first period. Second year of first period 22 caramels (70 g sugar) in two between meal portions. First year of second period 22 caramels per day in four portions</td>
<td>62</td>
<td></td>
<td>Dental caries was unchanged during the first year. Consumption of caramels led to a significant increase in caries increment, so much that caramels were withdrawn in the first year of second period. Withdrawal resulted in fall in caries increment to previous level.</td>
</tr>
<tr>
<td>8 toffees/d First year, first period low carbohydrate high fat diet. Then 8 toffees a day (40 g sugar) in second year first period at breakfast and lunch only. In second period given in between meals. Sucrose solution was taken at meals so sucrose intake was equal to other groups</td>
<td>40</td>
<td></td>
<td>First year, first period caries increment was low. Significant increase in caries in all three years when toffees were consumed. Greatest in third year.</td>
</tr>
<tr>
<td>24 toffees/d First period 24 toffees available throughout day. Toffees stopped at end of first period.</td>
<td>48</td>
<td></td>
<td>A very marked rise in dental caries increment during first period. Consumption of toffees was higher in females and so was caries increment. Issue of toffees was stopped before end of first period (because of increased caries) and consumption in-between meals was not allowed. This led to marked decrease in caries increment.</td>
</tr>
</tbody>
</table>
The Vipeholm study

- The first carbohydrate period was between 1947 and 1949 and the second carbohydrate period in which the regimens were changed slightly ran between 1949 and 1951.
The Vipeholm study

- 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 disappears on withdrawal of sugar-rich foods
  - Dental caries experience showed wide individual variation
The Turku Sugar Studies

- A controlled longitudinal study carried out in Finland in the 1970s
- Study investigated the effect of almost total substitution of sucrose in a normal diet with either fructose or xylitol on caries development
- Three groups of subjects (n = 125 in total)
- Subjects aged 12–53 years, with 65% being in their twenties,
- Consumed a diet sweetened with either sucrose, fructose, or xylitol for a period of 25 months
- Dental caries increment was monitored blind at six-month intervals by one person throughout the study and both carious cavities and precavitation lesions were monitored
The Turku Sugar Studies

The baseline conditions of the 115 subjects who completed the 2-year Turku sugar study

<table>
<thead>
<tr>
<th></th>
<th>Group</th>
<th>Fructose</th>
<th>Sucrose</th>
<th>Xylitol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total clinical and</td>
<td></td>
<td>13.9</td>
<td>11.0</td>
<td>13.4</td>
</tr>
<tr>
<td>radiographic carious surfaces</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Filled surfaces</td>
<td></td>
<td>29.4</td>
<td>27.3</td>
<td>29.8</td>
</tr>
<tr>
<td>DMFS</td>
<td></td>
<td>48.0</td>
<td>42.1</td>
<td>50.7</td>
</tr>
<tr>
<td>Number of subjects</td>
<td></td>
<td>35</td>
<td>33</td>
<td>47</td>
</tr>
<tr>
<td>Mean age (years)</td>
<td></td>
<td>26.2</td>
<td>27.2</td>
<td>29.1</td>
</tr>
</tbody>
</table>
The Turku sugar studies

• Foods were specially manufactured for the fructose and xylitol groups and intake of starch was not restricted but subjects were asked to avoid sweet fruits such as dried fruits since sugars in these foods could not be substituted.
The Turku Sugar Studies

• The xylitol group consumed xylitol-containing foods significantly less frequently than the sucrose or fructose groups consumed their sweetened foods and the overall intake of xylitol in the xylitol group was lower than that of sucrose or fructose in the other groups

• An 85% reduction in dental caries was observed in the xylitol group who had removed sugar from their diet
The cumulative development of decayed, missing or filled surfaces including cavitation and pre-cavitation carious lesions, diagnosed both clinically and radiographically, but not including secondary caries. At 24 months, differences between all groups were statistically significant (p< 0.01).
The Turku Sugar Studies

• The main conclusions of the Turku study are that substitution of sucrose with xylitol resulted in a markedly lower dental caries increment in both cavities and at the pre-cavitation stage.