Preventive Dentistry
5th Year- Dental Students
Al- Isra'a University
2019- 2020

Lec. 20: Microbiological Aspect of Dental Caries

By Professor Dr. Sulafa El Samarrai

Oral microbial ecology:

Oral cavity is an open growth system that offers diverse habitats where-in different species of micro-organisms can prosper. Microorganisms initially colonize the mouth after birth, naturally acquired from the mother. The main route of microbial transition is via saliva. Studies showed that oral streptococci and (G-ve species) in children is predominantly from the mother and this known as vertical transmission. When teeth begins to erupt it will exposed to oral environments, at this point dental plaque will form. Eruption of teeth form a novel habitats for microbial colonization, as teeth provide the only non-shedding surfaces within the body to which resident flora can attach.

Note: *Mutans streptococci and Streptococcus sanguinis generally appear in the normal mouth following tooth eruption.*

Resident microflora has a diverse composition, consisting of a wide range of G +ve and G - ve bacterial species, yeast and other types. Resident microflora contribute directly and indirectly to the normal development of the physiology, nutrition and defense systems of the host.

***Microbial homeostasis*;** reflects the stability of microorganism, and reflects the highly dynamic equilibrium between the resident microflora and local environment. Resident oral flora are adapted to use endogenous (host derived) nutrients for growth (as salivary proteins and glycoproteins; primary source for microbial growth). Thus salivary constituents play an important role in regulating the growth and metabolism of oral microflora. In addition, the salivary immune system play a role in the maintenance of a healthy mouth. Any environmental changes (as sugar intake, medications) lead to imbalances among microbial species increasing the predisposing factors for oral disease.

In order to persist and grow, microorganism have to attach to (hard surfaces as teeth). This aggregates is known as **the biofilm** (dental plaque).

Dental plaque is a diverse microbial community found on a tooth surface, embedded in a matrix of polymers of bacterial and saliva origin. Approximately 80 – 90 % of the wet weight of plaque is water, and 70 % of dry weight of plaque is bacteria and the remainder is a matrix of polysaccharides, salivary proteins and glycoproteins.

Dental plaque are responsible for many of the diseases common to the oral cavity including dental caries, periodontitis, gingivitis, and the less common peri -implantitis, however biofilms are present on healthy teeth as well.

Plaque forms via an ordered sequence of events, resulting in a structurally- and functionally-organized, species-rich microbial community.

Stages in plaque formation include:

1- ***Acquired pellicle formation***: It is acellular pertinacious film, started to form within seconds of a clean surface being exposed to the oral environment. It is the first step in plaque biofilm development, achieved through the adsorption of host molecules (glycoprotein) to the tooth surface. It has a permeable selective nature, thus protect tooth surface by restriction of ions transport from and to tooth surface and surrounding environment.

2- ***Transport of microorganisms and reversible attachment*** *(0- 24 Hr.):* a passive transport of oral bacteria to the tooth surface, involves a reversible adhesion process. By using weak, long-range physicochemical interactions between the pellicle coated tooth surface and the microbial cell surface (van Der Wall's attraction, and a repulsive electro static forces).

   Note: *van Der Wall's attraction is adhesive forces between small particles.*

3- ***Pioneer microbial colonizers and irreversible attachment (adhesin – receptor interactions)*****:** short-range interactions between specific molecules on the bacterial cells and the complementary receptor proteins on the pellicle surface occur. The first bacteria to adhere are cocci, and other aerobic (oxygen- tolerant) bacteria. In pits and fissures as well proximal surface the main organisms are Streptococci, Gram positive facultative rods and actinomycetes.

4- ***Co-aggregation /co-adhesion and microbial succession (1- 7 days):*** The pioneer bacteria create an environment that attract other types of bacteria, thus a gradual replacement of already existing bacteria will happen by other species more suited to the modified habitat. The co-adhesion (; co- aggregation) of the later colonizers to the already present biofilm is through adhesion – receptor interaction). These interactions build up the biofilm to create a more diverse environment, which includes the development of unusual morphological structures like corn-cobs and rosettes.

Note: *microbial succession is a shift in the microbial population from streptococcus – dominant plaque to actinimyces.*

5- ***Mature biofilm formation (climax community)7 days and more:***: multiplication and biofilm formation (including the synthesis of extra polysaccharides).

6- Detachment from surfaces

Microbial Composition of Dental Plaque:

There is a diversity in bacterial number and proportion between ***supra***- and ***sub*** gingival plaque. Further, there is a diversity in bacteria number, type, and proportion from time to time, and from site to site within the mouth in the same individual. ***The plaque composition determines its pathogenicity and this differs by types of tooth surface.***

The first bacterial to adhere to teeth are called (primary colonizer), as for those that arrive later as plaque mature are called (secondary colonizers). Generally the primary colonizers are not insufficient number to be pathogenic. The first bacteria to adhere are cocci especially, Streptococci (47-85%). Primary colonizers are tend to be aerobic (oxygen- tolerant), as Streptococci, Actinomycetes and (G +ve facultative rods). As thickness of plaque increases the O_2 level fall and other bacteria increase as (G –ve cocci). Several factors affect the amount and rate of bacterial composition as (tooth brushing, sugar consumption, oral immune system of saliva).

Dental Caries is a Microbial Disease:

The disease is the result of metabolic activities of microbial communities on teeth (; dental plaque). Thus the presence of microbial communities is considered to be a prerequisite for caries to develop. Evidences were derived

from experimental animal studies, human epidemiological and observational studies.

1- **Evidence from animal studies**:

a- Germ - free animals (; gnotobiotic animals) fed cariogenic diet, develop caries only after transfer of microflora from other animal.

b- Strains of cariogenic bacteria can be transferred from one animal to another, leading to caries. Thus dental caries is a transmissible disease.

c- Antibiotics and chemotherapeutic agents can arrest active lesion or prevent new lesion in animal models.

d- There is a specificity of bacteria to develop caries by type of tooth surfaces:

Tooth surface	**Types of Bacteria**
Smooth lesions	S. mutans, S. Salivarius, Actinomyces
Pits and Fissures	S. mutans, S. Sanguis S. Salivarius, S. mitior, Actinomyces, Lactobacilli
Root Caries (cervical)	Actinomyces, other anaerobic Bacteria
Approximal	Actinomyces, other G –ve bacteria, streptococci and S. mutans

2- **Evidence from human studies**:

a- Increase number of mutans streptococci and lactobacilli in saliva and plaque with increase in the prevalence and severity of dental caries.

b- Variation in types of bacteria by different tooth sites and carious lesions. S. mutans and lactobacilli is more cariogenic compared to other types of bacteria.

Virulence Factors of Cariogenic Bacteria:

Virulence (; cariogenic potential) is referred to bacterial properties that contribute to the caries formation. These are:

1- ***Acidogenicity***: acid producing ability, a prerequisite for cariogenisity.

2- ***Acid production rate***: the capacity of acid production vary by different bacteria. Some bacteria produce acid faster than others. For example, Streptococci produce acid in a faster rate than Actinomyces. Acids like lactic acid produces by metabolism of sucrose by bacteria.
3- ***Aciduric***: Certain groups of bacteria are more acid tolerant compared to others. Lactobacilli and S. mutans can grow in a medium of pH 5.0 – 5.2.
4- ***Formation of extracellular poly saccharide (ESP)***: It is the formation of insoluble ESP (**as glucans**), from sucrose. These ESP play an important role in **adherence** and **build- up** of microorganisms on teeth. Further, ESP, act as **a barrier** to the diffusion of acids from the plaque (i. e. prolong the concentration of acid in proximity to tooth surface).
5- ***Formation of storage poly saccharides***: Is the ability to convert a portion of sugar if present in excess to intra cellular storage poly saccharides. Later when exogenous carbohydrates exhausted bacteria utilize and metabolize these reserves for energy, the end results are acid formation.

Role of *mutans streptococci* in relation to dental caries:

- A positive correlation is present between the counts of mutans streptococci in saliva and plaque and increase prevalence, severity, and progression of dental caries. This is approved by animal studies as well as cross- sectional and longitudinal human studies.
- Possess cariogenic potential properties (acidogenic, Aciduric, produce ECP and intra cellular poly saccharides).
- Can be isolated from tooth surfaces immediately before development of dental caries.

Role of lactobacilli in relation to dental caries:

- A positive correlation is present between the counts of lactobacilli in saliva and plaque and caries activity as enamel, dentin as well as the root surface.
- Possess cariogenic potential properties(acidogenic, Aciduric, produce ECP and intra cellular poly saccharides).
- Un like streptococci, they are rarely isolated from plaque before development of carious lesions. It is believed that lactobacilli are involved in progression of deep carious lesion rather than initiation of

lesions. They are the pioneer bacteria in the advancing front of the caries lesion in dentine.

Note: *lactobacilli are poor colonizer of smooth surface*

Role of Actinomyces in relation to dental caries:

- *In vivo*- and *in vitro* studies reported association of these bacteria with root caries.
- A. viscosus were isolated from plaque samples taken from root caries.

Note: the role of Actinomyces in relation to dental caries is not fully clear..

Role of other bacteria in relation to dental caries:

Some species of bacteria may have a beneficial effect in relation to dental caries. Veillonella spp. (G +ve, anaerobic cocci) are unable to metabolize dietary carbohydrate, but instead they possess the ability to utilize lactate that is produced by other bacteria and convert it to a weaker and less cariogenic organic acid.

Hypotheses regarding the role of plaque in relation dental caries:

There have been different schools of thoughts on the role of plaque bacteria in the etiology of caries:

1- ***The "Specific Plaque Hypothesis***; proposed that, out of the diverse collection of organisms comprising the resident plaque microflora, ***only a few species are actively involved in disease***, such as Streptococcus mutans and Streptococcus sobrinus.

This proposal focused on controlling disease by targeting preventive measures and treatment against a limited number of organisms.

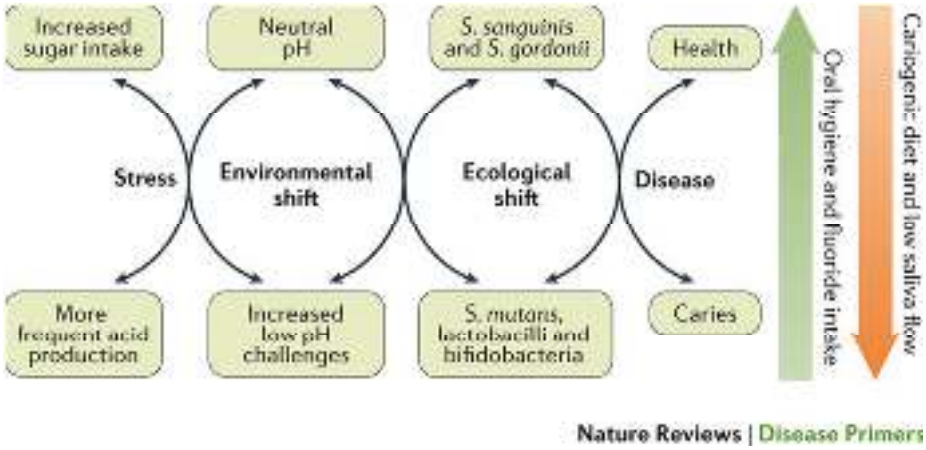
2- ***The "Non-Specific Plaque Hypothesis***; considered that disease is the outcome of ***the overall activity of the total plaque microflora***.

In this way, a heterogeneous mixture of microorganisms could play a role in disease.

3- ***The "Ecological Plaque Hypothesis;*** considered that the disease is a consequence of imbalances in the resident microflora resulting from changes in the local surrounding environmental conditions.

Caries is a result of changes in the environment due to acid production from the fermentation of dietary carbohydrates, which selects for acidogenic and acid-tolerating species such as mutans streptococci and lactobacilli.

Disease could be prevented not only by targeting the putative pathogens directly, but also by interfering with the key environmental factors driving the deleterious ecological shifts in the composition of the plaque biofilms.



Strategies of caries prevention according to plaque hypotheses:

This include the following**:**

1- **Inhibition of plaque acid production**: by fluoride-containing products or other metabolic inhibitors. Fluoride improves enamel chemistry and also inhibits several key enzymes, especially those involved in glycolysis and in maintaining intracellular pH.

2- **Avoidance between main meals of foods and drinks** containing fermentable sugars thereby reducing repeated conditions of low pH in plaque.

3- **Stimulation of saliva flow after main meals**, saliva will introduce components of the host response, increase buffering capacity, remove fermentable substrates, promote re-mineralization, and more quickly return the pH of plaque to resting levels.