Review Article

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Viridans Group Streptococci and the Oral Ecosystem

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ABSTRACT

The human oral cavity is the highly selective environment, which can be colonized by certain microbes. Viridans group streptococci are the most common bacterial isolates along with many other aerobic and anaerobic bacteria. S. salivarius is the most common viridians group streptococcus followed by S. mitis, S. sanguis, S. milleri, S. gordonii and S. mutans. The diverse habitat unique to the oral cavity together with a variety of nutrients is supportive to mixed population. These members of the resident oral flora, including viridians group streptococci, are responsible for colonization resistance, i.e., they prevent colonization / invasion by more pathogenic exogenous bacterial pathogens. Disruption of the oral ecosystem may lead to impairment of colonization resistance leading to higher rates of colonization by more pathogenic exogenous bacterial pathogens. Thus, viridians group streptococci normally present in the oral cavity play a significant role in oral health.

Keywords: *Viridans group streptococci, oral ecosystem, microbial diversity, colonization resistance*

Viridans Streptekok Grubu ve Oral Ekosistem

ÖZET

İnsan ağız boşluğu belirli mikropların kolonize olduğu oldukça özel bir ortamdır. Viridans streptokok grubu birçok aerobik ve anaerobik bakteriler ile birlikte en sık görülen bakteriyel türdür. S. salivarius S. mitis, S. sanguis, S. milleri, S. Gordonii ve S. mutans ile birlikte görülen en yaygın viridans streptokok grubudur. Çeşitli besinler ile birlikte ağız boşluğuna özgü ortam bu mikroorganizmaları destekleyicidir. Viridans streptokok grubu dahil olmak üzere yerleşik oral flora daha patojenik eksojen bakteriyel patojenler tarafından kolonizasyon ve invazyonu önleyen kolonizasyon direncinden sorumludur. Oral ekosistemin bozulması daha patojenik eksojen bakteriyel patojenler tarafından kolonizasyona neden olabilir. Böylece, ağız boşluğunda normal olarak bulunan viridians streptokok grubu ağız sağlığında önemli bir rol oynamaktadır.

Anahtar kelimeler: *Viridans streptekok grubu, oral ekosistem, mikrobiyal çeşitlilik, kolonizasyon direnci*

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INTRODUCTION

The oral cavity of the newborn infant is microbiologically sterile at birth. The process of acquisition of resident oral microflora begins soon after the birth within few hours. The mouth of the newborn baby is usually sterile. However, from the first feeding onwards, the mouth is regularly inoculated with microorganisms. By one month of age, virtually all infants are colonized with at least one species of viridans streptococcus. Colonizing microorganisms originate from the maternal vagina, the upper respiratory tract of mother, food, milk or water or may come from the saliva of individuals close to the baby. Acquisition of microorganisms from the environment may also occur (1-3).

The role of saliva in transmission of microorganisms has been confirmed conclusively. Bacteriocin-typing of strains has enabled the detection of transfer of S. mutans from mother to child via saliva (4). Similarly, comparisons of the DNA of a variety of oral bacteria indicated that the same strain was found within mother-child pairs and within family groups, and that different patterns are observed between such groups (5).

From birth, the human oral cavity is a highly selective environment, which can only be colonized by certain microorganisms (1). The predominant 'pioneer species' in the mouth are streptococci. S. salivarius usually becomes established within the first 48 hours of life (6). More recently, Pearce et al. (1995) have also identified S. mitis biotype I and S. oralis as early colonizers, in a study of streptococcal species isolated from the mouths of neonates at different sampling times between 1-3 days, two weeks and one month post partum (7). The ability of some pioneer viridans streptococci to produce immunoglobulin Al protease may influence their ability to survive in this habitat (8). With time, the metabolic activity of the pioneer community can modify its environment. Change in pH or redox potential or provision of new receptors or nutrients allows colonization by new organisms (9). Once established, bacterial species tend to persist in the mouths of infants (10). However, at a clonal level, there exists a high degree of diversity amongst strains and the turnover rate of these may be higher in children than in adults (11). Among more than 600 S. mitis biotype I isolates from two families, including two infants, collected four times at 3-monthly intervals, some persisting clones were found in adults but none in infants (12). The results from a study by Kononen and co-workers (1994) demonstrated a similar pattern for the oral anaerobe, Prevotella melaninogenica (13).

In the oral cavity, acquisition of viridans streptococci along with many other microorganisms continues with age. Species which prefer to colonize hard surfaces appear or increase in number once teeth have erupted. The oral microflora of teenagers differs from that of the five year-old children. Eighteen to 40% of five year old children are colonized with black-pigmented anaerobes; while 90% of teenagers aged 13-16 years harbor these organisms. It has been proposed that the increased prevalence of this bacterial group during puberty might be due to hormones entering the gingival crevice and acting as a nutrient source (9). The process of microbial succession continues until a stable situation or 'climax community', comprising highly diverse species of microorganisms is established (10).

Distribution of Viridans Group Streptococci (VGS) in the Oral Cavity

S. salivarius is the most common Viridans Group Streptococci (VGS) normally present in the oral cavity followed by S. mitis, S. sangius, S. millerii, S. gordoniia and S. mutans (2). Viridans group streptococci VGS have species-specific predilections for anatomic areas of the oral cavity and pharynx. For example, in the healthy adult mouth, S. sanguis and S. mitis biotype I are commonly associated with the buccal mucosa, whereas the pharyngeal mucosa is more likely to be colonized with S. salivarius (14). On the teeth, mutans streptococci and members of the anginosus and mitis groups are found as these organisms have a high affinity for hard surfaces. On the dorsum of the tongue, the major species found are S. mitis biotype II and S. salivarius (14).

In contrast to the oral microflora of adults, it has been found that S. sanguis is not generally isolated from the buccal mucosa of neonates and S. mitis biotype II rarely colonizes the dorsum of the tongue (7, 14). S. oralis was commonly recovered from the oral mucosa of neonates by Pearce and co-workers (1995) (7), however, it was found almost exclusively on the teeth of adults (14). In the adult mouth, on an average, streptococci represent 28% of the total cultivable microflora from supragingival dental plaque, 29% from the gingival crevice, 45% from the tongue and 46% from saliva (9).

Microbial Diversity in the Oral Cavity

Despite the activity of antimicrobial substances in saliva, the oral cavity has more complex and mixed flora. The normal oral microflora is a complex mixture of bacteria, fungi and protozoa. Occasionally, viruses are also present as a part of normal flora. Bacterial flora is the most predominant flora in the oral cavity; 500-600 different kinds of bacteria are normally present in the oral cavity (2). In addition to viridans group streptococci VGS, the mouth supports the growth of a wide variety of other bacteria. These include diverse aerobic and anaerobic bacterial species. Many of the bacteria are fastidious in their nutritional requirements and are difficult to culture and identify in the laboratory; many are obligate anaerobes (Table 1).

The diverse habitats unique to the oral cavity together with a variety of nutrients can support this mixed population. In addition, in dental plaque, gradients develop in parameters of ecological significance, such as oxygen tension and pH, providing conditions suitable for the growth and survival of microorganisms with a wide spectrum of requirements. The distribution of microorganisms is also related to their ability to adhere at a site, as well as to the need for their nutritional and environmental requirements to be satisfied. Many species of bacteria have been shown to adhere by specific molecular interactions between adhesins located on their cell surface and ligands on the host. These ligands are derived mainly from the acquired pellicle and mucus coat on enamel and mucosal surfaces respectively. Under the conditions found in the healthy mouth, no bacterial population has a particular advantage and numerous species can co-exist (15).

Table 1. *Bacterial genera found in the oral cavity*

	Gram positive	Gram negative
Cocci	*Micrococci* *Enterococcus* *Peptostreptococcus* *Streptococcus* *Staphylococcus* *Peptococci* *Stomatococcus*	*Moraxella* *Neisseria* *Veillonella*
Bacilli	*Actinomyces* *Bifidobacterium* *Corynebacterium* *Eubacterium* *Lactobacillus* *Propionibacterium* *Rothia* *Arachania* *Nocardia*	*Actinobacillus* *Campylobacter* *Capnocytophaga* *Centipeda* *Eikenella* *Fusobacterium* *Haemophilus* *Leptotricha* *Mitsuokella* *Porphyromonas* *Prevotella* *Selenomonas* *Simonsiella* *Treponema* *Wolinella* *Bacteroides* *Coliforms* *Proteus* *Campylobacterium* *Mycoplasma*

Persistence of the Oral Microflora and Colonization Resistance

The persistence of the resident oral microflora is dependent on the ability of these organisms to obtain nutrients and multiply in the mouth. Nutrients are derived mainly from the metabolism of endogenous substrates present in saliva and gingival crevicular fluid. Saliva is a complex mixture of the secretions of salivary and other glands of mucus membrane in the oral cavity. It is composed of 99.5% of water and 0.5% of solids containing 50% of organic substances such as proteins, lipids, enzymes, hormones, ammonia and urea, and 50% of inorganic substances such as chlorides, bicarbonates, sodium, calcium, potassium and dissolved gases, which play important role in oral ecology. Crevicular fluid also contains proteins, sodium, calcium, potassium, iron and various enzymes of host or microbial origin (2). Superimposed on these components are exogenous nutrients, which are supplied intermittently via the diet; the most significant of these are carbohydrates and casein. The concentration of nutrients will affect the growth rate and physiology of the microflora, which will change the pH resulting from microbial metabolism. The fluctuating conditions of nutrient supply and environmental change require the microflora to possess biochemical flexibility (16).

In the healthy mouth, members of the resident microflora, including viridans streptococci, prevent colonization / invasion by more pathogenic exogenous microorganisms; a phenomenon called 'colonization resistance.' This can be achieved by various means including competition for mucosal adherence sites, e.g., colonization of S. pneumoniae can be prevented by S. mutans and prevention of colonization of S. pyogens, Corynebacterium diphtheriae and E. coli by S. mitior S. mitis, and the production of bacteriocins. One such bacteriocin is hydrogen peroxide, produced by certain members of the mitis group, which exerts an inhibitory effect on the growth of competing bacteria (16). Enocin produced by S. salivarius is also inhibitory to other microorganisms. The indigenous species may also be more efficient in utilizing natural substrates in the mouth so that invading microorganisms cannot flourish. The metabolism of the resident microflora, producing changes in pH or redox potential, can also make conditions unsuitable for colonization by other microorganisms. Host factors also play a role in colonization resistance. Immune and innate host defenses also help to exclude invading microorganisms (9).

Disruption of the Oral Ecosystem

Colonization resistance may be impaired by factors which compromise the integrity of the host defenses or perturb the resident microflora (17). Classical examples are the use of broad spectrum antibiotics or cytotoxic chemotherapy but other more subtle mechanisms can apply. Fibronectin has been shown to prevent adhesion of Pseudomonas aeruginosa to buccal epithelial cells. Levels of fibronectin in seriously ill adults and in infants are lower than those in healthy adults and may account for the higher rates of colonization by gram-negative bacilli in these subjects (18). The ecology of the oral cavity also varies with diet. The regular intake of dietary carbohydrates can lead to the enrichment of aciduric and cariogenic microorganisms such as mutans streptococci, while poor oral intake in debilitated patients may also influence the microbial composition (19). The very diverse resident oral microflora with its characteristic composition exists, for the most part, in harmony with the host. However, components of this microflora can act as opportunistic pathogens when the habitat is disturbed or when microorganisms are found at sites not normally accessible to them (17).

The normal microbial flora of the oral cavity, VGS in particular, play key role in health of an individual. VGS prevent/interfere with colonization/invasion by exogenous bacterial pathogens either by simple competition with the pathogen or by producing inhibitory substances.

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