СТОМАТОЛОГИЯ/DENTISTRY

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ORAL FLUID AS A RISK FACTOR FOR CARIES DEVELOPMENT

Research article

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Abstract

The article discusses the conditions and factors contributing to the development of caries: microflora, dental plaque, the role of saliva and its function of surface tension. The role of high concentrations of hydrogen ions in the mechanisms of hydroxyapatite destruction, the mechanisms of conjugation of mucin proteins and low viscosity of oral fluid in caries-resistant patients is revealed.

A cariogenic situation occurs when one or more cariogenic factors act on a tooth and make it susceptible to the action of acids. It develops faster in conditions of a decrease in the protective properties of saliva and the resistance of the hard tissues of the teeth. The triggering factors are the microorganisms of the oral cavity and the presence of carbohydrates in it. The cariogenic situation is manifested by such clinical symptoms as irrational oral hygiene, the presence of plaque and tartar deposits, bleeding gums, and numerous chalky spots on teeth.

Caries resistance is ensured by the special structure of tooth enamel, which has low permeability to various substances, proper formation of hard tissues, sufficient amount and high remineralizing potential of saliva, factors of local immunity of the oral cavity, good hygiene and self-cleaning of the dental surface.

Keywords: caries, oral fluid, saliva properties, saliva viscosity, saliva pH, dental plaque, saliva surface tension, opportunistic microorganisms.

ЖИДКОСТЬ ПОЛОСТИ РТА КАК ФАКТОР РИСКА РАЗВИТИЯ КАРИЕСА

Научная статья

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Аннотация

В статье рассматриваются условия и факторы, способствующие развитию кариеса: микрофлора, зубная бляшка, роль слюны и её функция поверхностного натяжения. Раскрывается роль высоких концентраций ионов водорода в механизмах разрушения гидроксиапатитов, механизмы сопряжённости белков-муцинов и низкой вязкости ротовой жидкости у кариесрезистентных пациентов.

Кариесогенная ситуация возникает тогда, когда один или несколько кариесогенных факторов действуют на зуб и делают его восприимчивым к действию кислот. Она развивается быстрее в условиях снижения защитных свойств слюны и резистентности твердых тканей зубов. Пусковыми факторами являются микроорганизмы полости рта и наличие углеводов в ней. Кариесогенная ситуация проявляется такими клиническими симптомами: нерациональная гигиена полости рта, наличие отложений зубного налета и камня, кровоточивость десен, многочисленные меловидные пятна на зубах.

Кариесрезистентность обеспечивается особой структурой эмали зубов, которая обладает низкой проницаемостью для различных веществ, правильным формированием твердых тканей, достаточным количеством и высоким реминерализирующим потенциалом слюны, факторами местного иммунитета полости рта, хорошей гигиеной и самоочищением поверхности зубов.

Ключевые слова: кариес, жидкость полости рта, свойства слюны, вязкость слюны, pH слюны, зубной налет, поверхностное натяжение слюны, условно-патогенные микроорганизмы.

Introduction

The question of the mechanism of caries formation and the influence of oral fluid on its development has been in the focus of research attention for some years. To study this topic, a retrospective analysis of publication activity on the elibrary.ry scientific electronic library platform for 2019–2023 on the current issue was conducted. The data of the analysis is summarized in the table below.

Table 1 - Analysis of publication activity using keywords

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Keyword	"Caries"	"Oral fluid and dental caries"	"Saliva properties and dental caries"	"Viscosity and caries"	"pH and caries"	Number of publications per year
2019	687	24	3	2	6	722
2020	672	13	5	3	5	698
2021	603	14	2	1	3	623
2022	539	21	8	1	10	579

Keyword	"Caries"	"Oral fluid and dental caries"	"Saliva properties and dental caries"	"Viscosity and caries"	"pH and caries"	Number of publications per year
2023	544	16	5	5	6	576
Total	3045	88	23	12	30	3198

It draws attention to the fact that for 5 years the relevance of studying the mechanisms of caries and the role of oral fluid in this process has been maintained. We see that the greatest number of scientific articles for the whole period of study of publication activity falls on the topics "caries" and "the role of oral fluid in the formation of caries".

Carious process is a local pathological process that manifests itself after the eruption of teeth, and which is characterized by demineralization and softening of the hard tissues of the tooth with the subsequent formation of a cavity defect [1].

The authors believe that the main condition for the development of dental caries is the formation of dental plaque, due to which the local demineralizing effect of the microbial flora inhabiting it (production of lactic acid as a result of glycolysis) is created.

Main results

Dental plaque is a soft formation that consists of food residues and products of bacteria that multiply on them. One of the representatives are S. mutans, which synthesize extracellular polysaccharides — glycans — from sucrose. They promote the attachment of bacteria to tooth enamel and stabilize the plaque matrix [2].

Dental plaque includes up to 70% of microorganisms and has a mesh structure with semi-permeable properties. It is easily penetrated by carbohydrates, which further have a destructive effect on the tooth tissue. Microorganisms use carbohydrates appearing in the oral cavity in the process of glycolysis, which supports the appearance of a large number of organic acids (lactic pyruvic acid, formic acid, etc.), they are a source of H+ ions in the oral cavity [3].

Under the conditions of organic acids' formation on enamel, hydrogen ions penetrate deeply into the porous interprism spaces, and cause subsurface demineralization, microspaces between enamel prism crystals increase [4].

High concentrations of H^+ (acidosis) do not lead to Ca^{2+} replacement, but to acidic destruction of hydroxyapatites, because H^+ is many times smaller than the Ca^{2+} ion.

$$Ca_{10}(PO_4)_6(OH)_2 + 2H^+ \rightarrow 10Ca^{2+} + 6PO_4^{3-} + 2H_2O$$

This allows microorganisms and their products to penetrate more intensively into the enamel microdefects. A cone-shaped lesion is formed, which spreads into the depth of the tooth [3].

It is also worth noting that during the ingestion of carbohydrate foods, the microflora of dental plaque instantly assimilates saccharides. This creates a "metabolic explosion", and the acidity in the oral cavity rises sharply. After half an hour, the acidic environment is neutralized by saliva, but when carbohydrates are reintroduced, the pH level under the plaque decreases again, resulting in damage to the enamel due to increased permeability.

Normally, tooth enamel is in a state of dynamic equilibrium between the ongoing processes of de- and remineralization. In the absence of proper hygiene — single point bacterial colonies attached to the teeth merge to form bacterial masses of significant size (dental plaque) [1].

Saliva helps to remove food debris from the surface of the teeth and oral cavity, which reduces pathogenic bacteria that cause dental caries [5]. Saliva (oral fluid) is a viscous liquid with a pH of 5.8–7.6, the composition of which varies according to the rate of its secretion. About 99–99.4% of saliva is water. The remaining 1–0.6% is mineral and organic matter. Inorganic components of saliva are in the form of dissolved in it anions of macronutrients — chlorides, phosphates, bicarbonates, rhodanides, iodides, bromides, sulfates, as well as cations Na+. K+. Ca2+ Mg2+.

On average, 1–2.5 liters of saliva is secreted per day. The norm of saliva secretion is 2 ml per 10 minutes, the average volume of oral fluid in the oral cavity is 1–2 ml of saliva.

Caries is accompanied by a decrease in salivation by 25%, which causes deterioration of the mechanical and chemical cleansing of the oral cavity, dry mucous membranes.

One of the properties of oral fluid is its viscosity. The viscosity of saliva is due to the content of special proteins-mucins (15%) (Latin mucus — mucus) or mucoproteins. Mucins have viscosity, elasticity and adhesiveness. The biological role of mucins is mechanical protection (wetting and lysing of food, formation of insoluble film - pellicle, which reduces the permeability of enamel). On the viscosity of oral fluid depends on the possibility of self-cleaning and removal of food residues from the surface of the teeth. High saliva viscosity is in caries susceptible people. Low saliva viscosity — in caries-resistant people [6].

More than 50 different enzymes are identified in the composition of mixed saliva. The sources of which are salivary glands, microorganisms, leukocytes and epithelial cells.

One of the groups of enzymes is glycosidases, the role of which is particularly important in the execution of the protective function. Depending on the pH value, the enzymatic activity changes. At pH 8.0, hydrolysis of carbohydrates of the bacterial wall is carried out — a protective function. However, a decrease is observed at pH values below 7.0 (hydrolysis of carbohydrates of membranes, mucous membranes, saliva proteins).

Lysozyme is a representative of glycosidases and has a pronounced antibacterial effect. Lysozyme (muramidase) cleaves the glycosidic bond between N-acetylglucosamine and N-acetylmuranic acid residues in the polysaccharide chains of the bacterial cell wall and leads to their death.

At pH values less than 7.0, hyaluronidase activity increases. It destroys the matrix and increases the permeability of enamel at various stages of the carious process. β-glucuronidase cleaves carbohydrate components of mucin, disrupts the formation of pellicle, and increases the probability of caries development.

Alkaline and acidic phosphatases are distinguished depending on the enzyme activity and pH value. The activity of both phosphatases in mixed saliva is usually increased in gingivitis and periodontitis. There are conflicting reports on the changes in the activity of these enzymes in caries.

Acid phosphatase is active at pH 4.8–5.0, is contained in lysosomes and enters mixed saliva with secretions of large salivary glands, as well as from bacteria, leukocytes and epithelial cells. Up to 4 isoenzymes of acid phosphatase have been shown to be present in saliva.

Alkaline phosphatase is most active at pH 9.1–10.5. Alkaline phosphatase activity is low in salivary gland secretions of healthy humans, and its origin in mixed saliva is attributed to cellular elements and dental microorganisms [4].

Conclusion

1. When the pH decreases, there is an increase in enamel permeability. The process of glycolysis occurring in dental plaque provides acidification of the environment and thus increases enamel permeability.
2. Decreased salivation leads to impaired mechanical and chemical cleansing of the oral cavity
3. When viscosity increases, there is a decrease in the saponification and cleansing function of saliva and the formation of a protective layer is impaired.
4. Hyaluronidase has the ability to increase enamel permeability, and alkaline phosphatase has the ability to decrease it. Both saliva and microorganisms can act as sources of enzymes.

Конфликт интересов

Не указан.

Рецензия

Все статьи проходят рецензирование. Но рецензент или автор статьи предпочли не публиковать рецензию к этой статье в открытом доступе. Рецензия может быть предоставлена компетентным органам по запросу.

Conflict of Interest

None declared.

Review

All articles are peer-reviewed. But the reviewer or the author of the article chose not to publish a review of this article in the public domain. The review can be provided to the competent authorities upon request.

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