Analysis of Antibiotic Resistance of Pathogenic Bacteria in Oral Cavity

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ABSTRACT

This research paper examines the representative types of antibiotics used in dentistry and analyzes through susceptibility tests how the resistance to antibiotics of certain pathogenic bacteria has changed chronologically. The research investigates the pattern of how antibiotic resistance has changed over time and derives countermeasures accordingly.

Keywords: oral health, antibiotic susceptibility test (AST), resistance, pathogenic bacteria, dentistry

INTRODUCTION

Definition

A lot of microorganisms live in our oral cavity. This is because microorganisms and higher animals - here, humans - have long competed for survival. As a result, they started to live in a cooperative relationship (symbiosis). Humans are exposed to microorganisms as they coexist with the external environment. At the same time, the whole body - the skin, the eyes, the genitals, the mouth - is in the body. Exposure to the outside air causes microbes to settle and survive. The set of microorganisms configured in this way is called a standard microbial gun, and the composition or number of microorganisms varies depending on the body part.

There are more than 200 kinds of bacteria in our bodies. Microflora is prokaryotic cells that have small and simple structures (bacteria) that do not have a membrane attached to them or a small organ in the cell. They are divided into gram-positive and gram-negative bacteria; they have differences in that their cell wall. Microflora produces antibodies and acts as antigens. They help develop natural immunity by making antibodies to various bacteria in the standard bacterial gun. It prevents the invasion of other pathogens. It defeats external pathogens that invade the mouth, intestines, skin, and vagina. However, there are some cases where it causes infection. When physical force is applied to the place where the microbial gun is created, or changes in the physiological and biochemical environment occur, the balance of the distribution or number of microorganisms becomes irregular, causing disease.

Microflora in the Oral Cavity

In the mouth, standard microbial guns exist in the tongue and tonsils and are balanced. In addition, when a specific microbial group multiplies among normal bacterial guns, diseases in the mouth may develop. Most of the conditions that occur in the area of the oral cavity, such as dental caries, periodontal disease, dimensional and peristaltic infections, oral-facial tissue, or bone infection, are oral infectious diseases. Here, infection means pathogenic microorganisms (pathogens), such as bacteria and viruses, enter the host, press down on normal host defences, and grow in friendly organs or tissues.

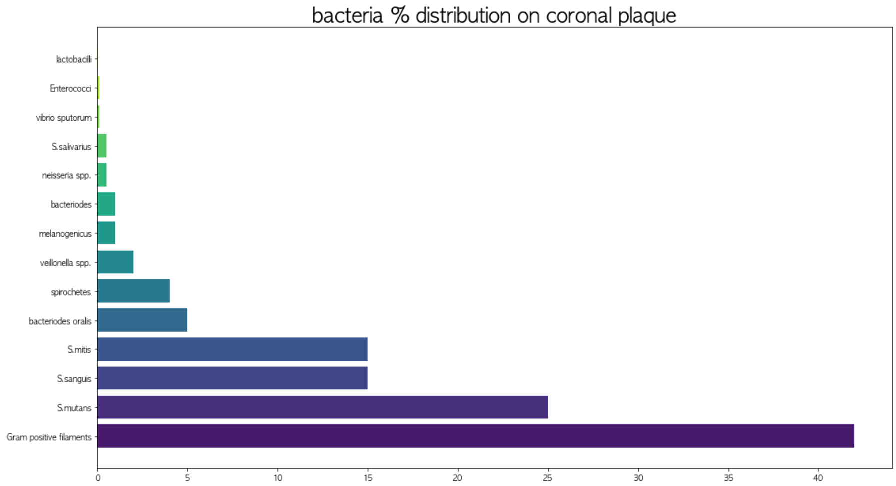
Thus, normal microflora is classified into two groups. First is the *Residual Flora*, the composition of certain species and trees, long settlement periods, and rarely cause infection. Second is *Transient Flora*: temporary settlement, no pathogenic or potential pathogenic, and the frequency of infection depending on the immune state is high. There are many different micro-environments in the mouth, and the ecology of these micro-environments is complex and diverse. Sugar and amino acids provided intermittently from saliva and food provide nutrients for microbial growth (about 700 species).

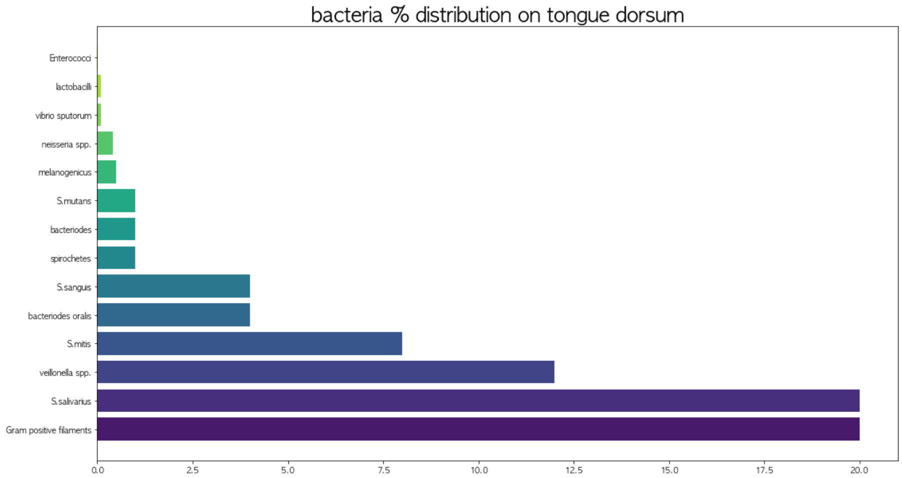
The table below shows the types of bacteria in our oral cavity based on their location.

Bacteria	Gingival crevice	Coronal plaque	Tongue dorsum	Buccal mucosa	Saliva
Streptococcus salivarius	<0.5	<0.5	20	11	20
Streptococcus mitis	8	15	8	60	20
Streptococcus sanguis	8	15	4	11	8
Streptococcus mutans	?	0-50	<1	<1	<1
Enterococci	0-10	<0.1	<0.01	<0.1	<0.1
Gram positive filaments	35	42	20	?	15
Lactobacilli	<1	<0.005	<0.1	<0.1	<1
Veillonella spp.	10	2	12	1	10
Neisseria spp.	<0.5	<0.5	<0.5	<0.5	<1
Bacteroides oralis	5	5	4	?	?
Bacteroides	6	<1	<1	<1	<1
melanogenicus	5	1	<0.5	<0.5	?
Vibrio sputorum	2	<0.1	<0.1	<0.1	<0.1
Spirochetes	3	4	1	?	<1
Fusobacterium spp.					

Data Visualization via Python

Each oral section has a different distribution of bacteria. The graphs below are visualized to identify the bacteria distribution in coronal plaque and tongue dorsum. The Matplotlib program is used to draw a diagram. The code is also included.





Disease outbreak

Oral diseases occur as specific microbial communities proliferate. Each disease has different causative organisms. Below are some examples.

Dental Caries

When Plaque (bacterial membrane formed on the surface of teeth) is decomposed by bacteria such as sugar and starch left in the mouth, it attacks the tooth enamel on the surface of the baby's teeth. It damages it, resulting in dental caries. When Acid bacteria and Fermented carbohydrates are added, it turns to Organic acids, resulting in the Dissolution of tooth structure (deionization). This results in the formation of cavities by activating streptococcus mutants (S.mutans), a bacteria that reduce saliva outflow and causes cavities.

Periodontal Inflammation

Treatment of periodontal tissue, including gums, periodontal ligament, and alveolar bone in specific microbial habitats under the gingiva, turns to the expression of toxic factors (proteases, leukotoxin) and then destructive immune response. The cause of the periodontal disease is mainly bacteria in the mouth. Flags are attached to teeth and cause infections. If the tooth is not removed correctly by brushing, inflammation occurs and the area of the tooth cavity (space between teeth and gums) surrounding the neck of the tooth becomes deeper. Support tissue is lost inside, forming a periodontal sac around the tooth. These periodontal sacs become deeper over time and provide a larger space for toxic bacteria to live in. P. gingivalis, T. forsythensis, etc., increase and cause periodontitis.

Dental clinics fight against pathogens through antibiotic prescriptions for these oral infectious diseases. However, excessive use of antibiotics increases pathogens' resistance, causing treatment problems. Recently, more resistance has begun to develop due to the over-prescription of antibiotics and the discontinuation of arbitrary treatment of patients.

Antibiotic

To begin with antibiotics, they are drugs made against microorganisms. Types include antifungal drugs, antiviral drugs, and antifungal drugs, among which antifungal drugs are drugs to fight against bacteria. The world's first antibiotic was made by Alexander Fleming penicillin in 1928. However, due to the emergence of resistant bacteria, penicillin currently has little effect. There are two mechanisms for acquiring bacterial resistance; the first is natural resistance, which means that bacteria naturally gain resistance to antibiotics. In this case, resistance is when bacteria multiply above the concentration of antibiotics that can clinically reach plasma or tissue. The second case refers to when bacteria that have developed antibiotic resistance by acquiring resistance genes.

Antibiotics are generally used in dental procedures to treat odontogenic and non-odontogenic impacts, local inspection, and prevention. These antibiotics have no problem even if they are slightly administered. The first is sterilization, which kills bacteria. However, in the case of antibiotics with a bacteriostatic action that prevents bacterial growth, it is necessary to adjust the concentration of certain drugs in the body to see proper medicinal effects. Therefore, the patient should not temporarily stop taking it in the middle.

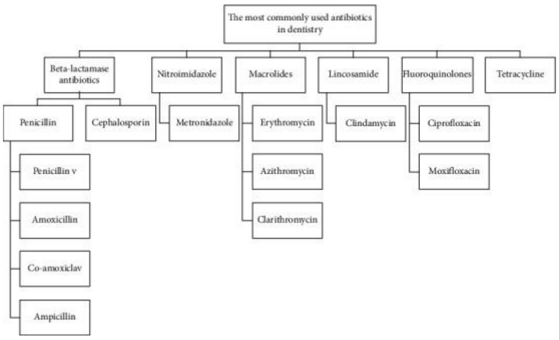
The table shows the most prescribed antibiotics.

Table 1

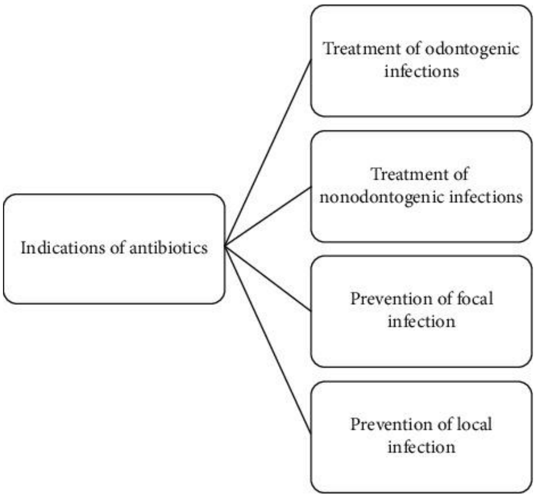
Different rates of antibiotic prescription by dentists [10].

Antibiotic	Prescription rate (%)
Amoxicillin	51.1
Amoxicillin + clavulanic acid	24
Clindamycin	6.6
Azithromycin	5.3
Clarithromycin	4.4
Doxycycline	3.6
Spiramycin	2.2
Erythromycin	1.2
Ciprofloxacin	0.2
Cefadroxil	0.1
Minocycline	0.1
Cefuroxime	0
Others	1.1

The antibiotics are divided into branches by their functions. reference [3]



This is the procedure of the dentist prescribing the antibiotic.



Antibiotic Resistance

Antibiotic resistance testing is a sensitivity test that measures how sensitive microorganisms react to antibacterial agents. Susceptibility tests detect a microbe's vulnerability to antimicrobial drugs by exposing a standardized concentration of organisms of specific concentrations. Bacteria and bacteria can always be resistant to bacteria and bacteria. This means that once used to kill or disrupt growth; the antimicrobial agent is no longer effective. Sensitivity testing can be used if the culture is positive for pathogens. The test does not guarantee susceptibility inhibits pathogenic microorganisms; it is an appropriate choice for treatment. Medium comes out when it is effective in high doses or more often prescribed, or only in certain body parts where antibacterial agents are permeated at appropriate concentrations. If the resistance outcome is ineffective in hindering microbial growth, it is not a suitable choice for treatment.

The widespread use of antibiotics has dramatically reduced the incidence of specific bacterial diseases and increased diseases caused by bacteria resistant to antibiotics. To reduce antibiotic resistance, the correct use of antibiotics is the most important. For this, proper selection of antibiotics is essential because the causative bacteria vary from infectious disease to infection. Unlike other pharmacological groups, antibiotics have a particular element called the "antibacterial spectrum (antibacterial range)," so their efficacy should be evaluated in two aspects of practical bacterial indications. In each case test, it is essential to try to detect causative microorganisms as much as possible and to understand the characteristics of antibiotics (antibacterial spectrum, resistance, frequency, safety, pharmacokinetics, and drug economics aspects) to be developed by examining changes in drug behavior according to subjects and groups.

The antibiotic sensitivity test can be tested in two ways. The first test is the minimum inhibitory concentration (MIC), which indicates the lowest concentration of drugs that suppress bacterial growth and the concentration that completely stops development. The second is the minimum bacterial concentration (MBC), which shows the lowest concentration of antibacterial agents that induce bacterial death and the maximum dilution concentration at which no bacterial growth is found. Sterilizing antibiotics inhibit cell wall synthesis and cell membrane function. It is the penicillin and cephem systems. Antibiotics with bacteriostasis inhibit protein synthesis and nucleic acid synthesis. It includes tetracycline, chloramphenicol, an amino sugar, and macrolide.

Analysis of Experiment for Dental Caries

Antibiotics, which are used to treat diseases, last longer when resistance develops and require the use of other drugs. Antibiotics on the market mustn't build resistance because the disease cannot be cured if they do not work effectively. This resistance can be seen through the Susceptibility test. The results of the Susceptibility test for the dental caries causative agent are analyzed by year to determine how resistance to antibiotics has changed by comparing the degree of resistance in the past and the present.

MATERIALS AND METHODS

To find out how resistance to dental caries has changed, an analysis of resistance by the time difference between the pathogenic bacteria s.mutans and s.mitis is made. It compares how the susceptibility rate of antibiotics changed from the test for dental caries conducted in the 2010s and 2020s. The compared antibiotics are ampicillin, cotrimoxazole, erythromycin, gentamicin, and tetracycline. The resistance test is used from 2016 research by Yadav (reference [4]) and 2021 research by Phillips (reference [5]).

Streptococcus mitis - susceptibility rate

	2016	2021
ampicillin	59.38%	0%
cotrimoxazole	78.16%	0%
erythromycin	56.25%	50%
gentamycin	71.88%	0%
tetracycline	21.88%	0%

* S.mitis from dental caries.

Antibiotic Resistance Pattern of S.mitis:

Antibiotics with 100% resistance reactions are ampicillin, cotrimoxazole, gentamycin, and tetracycline. In 2016, cotrimoxazole was the most resistant and effective antibiotic for s.mitis, but in 2021, erythromycin showed the least resistance. The susceptibility of most antibiotics decreased in 2021 compared to 2016. This means that there are more cases in which antibiotics no longer listen. The antibiotics with the most considerable % change arecotrimoxazole and gentamicin. These two antibiotics were the least resistant in 2016, cotrimoxazole fell from 78.16% to 0%, and gentamicin fell from 71.88% to 0%.

Streptococcus mutans - susceptibility rate

	2016	2021
ampicillin	73.08%	11.9%
cotrimoxazole	80%	0%
erythromycin	100%	72.8%
gentamycin	100%	0%
tetracycline	39.24%	1.98%

* S.mutans from dental caries.

Antibiotic Resistance Pattern of S.mutans:

Antibiotics with 100% resistance reaction are cotrimoxazole and gentamycin.

In 2016, the least resistant and effective antibiotic for s.mutans was erythromycin, and in 2021, erythromycin showed the least resistance. The susceptibility of most antibiotics decreased in 2021 compared to 2016. This means that there are more cases in which antibiotics no longer listen. The antibiotics with the most considerable % change are cotrimoxazole and gentamicin. These two antibiotics were the least resistant in 2016, cotrimoxazole fell from 80% to 0%, and gentamicin fell from 100% to 0%.

Antibiotic Resistance Analysis on Dental Caries:
In 2016, the antibiotics that had the best effect on dental carriers were cotrimoxazole, erythromycin, and gentamicin, but in 2021, all antibiotics except erythromycin developed efficiency of 0% and became resistant. Overall, the resistance to antibiotics has increased. Therefore, it would be best to prescribe erythromycin for dental caries in the future.

CONCLUSION

Just like the case of dental caries, plenty of dental diseases' susceptibility rate has decreased. Efforts to maintain the susceptibility rate are needed. The conclusion we can come up with through this research is, first, that we should try not to overprescribe, and second, that we should find new materials for fighting resistance. Recently, plant extracts (Sephora, fig, gamguk, omija, cloves, mulberry leaves, and arrowroot) that inhibit the growth of oral bacteria have shown that there is an antibiotic effect for four types of F. nucleatum, which play an important role in the formation of the dental bacterial membrane. Therefore, the essential oil is expected to be used as a substitute for antibacterial agents.

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