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RESEARCH ARTICLE

THE EFFECT OF DENTAL IMPLANTS ON AEROBIC BACTERIA COLONIZATION IN THE ORAL CAVITY AND THE ANTIBIOTIC PROFILE OF COMMON ISOLATED AEROBIC BACTERIA

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Abstract

Background and aims: The mouth's microflora may alter as a result of dental implants. The purpose of this study was to examine the composition of aerobic bacteria in patients with dental implants and those who had natural teeth (without implants) as well as the response of those bacteria to antibiotic treatment.
Methods: Bacteriological tests were performed on 72 patients (36 dental implants and 36 natural teeth) who visited dental clinics run by Sana'a University's Faculty of Dentistry and private dental clinics. Antibiotic susceptibility tests and culture trials were carried out at the National Center for Public Health Laboratories (NCPHL) in Sana'a, Yemen. Swabs were taken from the mucous membrane of the palate and the dorsum of the tongue from both groups, and cultured on selective and non-selective solid medium. Then bacterial growth was identified by standard methods.
Results: In implant patients, the rate of bacterial isolates from the palate and tongue was slightly higher for potentially harmful bacteria such as *E. coli* (8.3% in tongue implant patients vs. 2.8% in non-implant patients) and *Pseudomonas aeruginosa* (5.6% versus 0%). While in *viridians Streptococcus* including *S. mutans*, there was a higher colonization rate in implants patients (83.3% in the palate verses, 75% in the palate of individuals without implants). A low level of oxacillin resistance (5.1%) in *S. mutans* isolates but *S. mutans* had a substantial level of tetracycline resistance (55.93%), 11.9% for co-trimoxazole, 10.2% for erythromycin, and just 1.7% for clindamycin.
Conclusion: The study found that pathogenic bacteria like *E. coli* and *Pseudomonas aeruginosa* were isolated from the palate and the back of the tongue swabs at a slightly elevated rate in implant patients; also colonization rates of *Streptococcus viridians*, including *S. mutans*, were higher in implant patients compared to those without implants. There was a significant levels of antibiotics resistance in *S. aureus*, CoNs, and *S. viridians* oral isolates in both groups of tested individuals.
Keywords: Antibiotic susceptibility testing, micro flora of the mouth, normal teeth, oral cavity, dental implants.

INTRODUCTION

Oral microbiology is primarily concerned with the study of oral bacteria, as well as their interactions with other oral microbes and the host. The environment in the human mouth is optimal for the growth of the specific bacteria that live there since it provides a source of nutrients and water as well as a temperate temperature. The mechanical movement from the mouth to the stomach, where hydrochloric acid kills

acid-sensitive microorganisms, is resisted by oral-resident microbes adhering to the teeth and gums[1,2]. Researchers have discovered that oral bacteria have evolved strategies to control their surroundings and avoid or alter the oral environment of their hosts. The mucosal epithelium and dental surfaces fill the ecological niche created by bacteria[1,3]. The pH and oxygen content and availability on some mouth surfaces, as well as mechanical forces acting on those surfaces, the movement of saliva and fluids through the oral cavity, and the host's age, have all been shown to influence bacterial colonization in the oral cavity. This means that the loss of teeth and their replacement with dental implants or dentures may change the structure of those surfaces[1,3,6]. Despite this, a strong intrinsic host defense system constantly checks bacterial colonization and prevents bacterial penetration of local tissues. A dynamic balance exists between dental plaque bacteria and the host's inherent defense system[4]. The function of the oral microbiota in the two major dental illnesses, periodontal disease and dental caries, is of particular interest[1]. Furthermore, research has linked poor oral health to the potential of oral bacteria to assault oral tissues and the body, affecting teeth, heart health, and cognitive function[5]. Today, dental implants are a significant therapy option for individuals who need oral rehabilitation due to tooth loss. The routine use of dental implants may result in an increase in peri-implant illnesses and implant problems. As a result, implant dentistry clinicians need to understand the etiology, impact on normal flora colonization, causes, categorization, and treatment protocol of peri-implant disorders. When there is a negative balance between bone creation and resorption within the basic multicellular unit, bone loss and skeletal injury result6. Implant success has been discovered to be influenced by a number of internal (host) and external (surgery or implant) variables, including oral colonization of pathogenic microorganisms. Bone loss occurs during the postoperative recovery phase for a variety of reasons, including severe surgery, bacterial infiltration, and the host's latent healing capacity[6,8]. Even though pathogenic bacterial adhesion may be one of the major causes of cortical bone loss, exposure to a rough surface on the implant due to other factors such as surgical or occlusal trauma has been shown to stimulate bacterial adhesion to the implant and biofilm formation that may lead to inflammation of the soft tissue and bone infection (peri-implantitis)6·9. Peri-implantitis is frequently defined as an inflammation of soft tissue accompanied by bone loss of more than 0.5 mm6·9. However, there is disagreement over the definition of mucositis, with some authors suggesting that it only involves a soft tissue lesion and others suggesting that it also involves bone loss of less than 0.5 mm, comparable to peri-implantitis[9].

Antimicrobial resistance (AMR) is currently the biggest public health problem, and the number of AMR bacteria in various hospital departments is rising dramatically[1,10-16]. Oral bacteria such as *Staphylococcus aureus*, the *Streptococcus viridans* group, and *Enterobacteracea* are also known to cause oral infections as well as systemic illnesses such as endocarditis, pneumonia, and others[1,6]. The goal of this study was to look at the composition of aerobic bacteria in individuals who had dental implants vs those who had natural teeth (no implants), as well as how those bacteria responded to antibiotic therapy.

MATERIALS AND METHODS

Bacterial examinations were performed on 72 people (36 dental implant patients: 36 natural teeth) over the course of three months, beginning in December 2022 and ending in February 2023, at the Faculty of Dentistry, Sana'a University, Yemen, and private dental clinics (Al-Mortadda Dental Clinics, Al-Kahara Dental Clinics) in Sana'a, Yemen.

Microbiological procedure

Cultivation and antibiotic sensitivity testing were carried out at the National Center for Public Health Laboratories (NCPHL) in Sana'a, Yemen. Swabs were collected from the mucous membranes of the palate and tongue dorsa of both implant patients and people with natural teeth. Under oxygenated and microaerophilic (5% CO_2) conditions, cultures were carried out on selective and non-selective solid medium, as well as media enriched with 5% blood. Standard bacterial identification and culture procedures[17] were utilized.

Antibiogram: The disc diffusion method was used to determine the antibiotic susceptibility profile. The inoculums were modified to correspond to 0.5 McFarland standards of turbidity, then swabbed onto Brian heart infusion agar and left to dry for 10 minutes[17-19]. The susceptibility to eight non-lactam antibiotics, including erythromycin (15 mg), gentamicin (10 mg), amikacin (30 mg), ciprofloxacin (5 mg), clindamycin (2 mg), and vancomycin (30 mg), was then assessed using antibiogram profiling (Oxide, USA). After 24 hours of aerobic incubation at 37°C, the inhibition zone was determined. Each antibiotic's experiments were carried out three times. Clinical and Laboratory Standards Institute (CLSI) methods was used to analyze the results[18,19].

Ethical Consideration: The Faculty of Medicine and Health Sciences at Sana'a University granted approval for this study under the number 2781, dated October 13, 2022, to its Medical Ethics and Research Committee. All procedures adhered to the review committee's ethical criteria. The subjects who were chosen provided written informed permission.

Statistical Analysis: Epi-info Statistics version 7 was used for data analysis. The rates of bacteria isolated were expressed as the percentage that was compared between cases and controls. Sensitivity to antibiotics was also expressed as (%) and antibiotic resistance for tested antibiotics was compared between cases and controls.

RESULTS

The study included 36 dental implant patients, with a 61.1% male to 38.9% female ratio and ages ranging from 37 to 62, with a mean age and standard deviation

of 49.5 and 6.8 respectively. Ages 46 to 55 made up the majority of the participants (52.8%) (Table 1). Regarding the quantity of implants, 3.3 0.91 implants are the mean and standard deviation. 41.7 percent of individuals had three implants, and 30.6% had four. Most patients (61.1%) had implants for a period of time ranging from 13 to 24 months, with a mean and standard deviation of 17.8 and 6.5 months, respectively.

Table 1: General characteristics of implant patients participate in the study.

Characters	Number (%)
Sex	
Male	22 (61.1)
Female	14 (38.9)
Ages	
≤45	10 (27.8)
46-55	19 (52.8)
≥56	7 (19.4)
Mean age	49.5Years
SD	6.8 Years
Mode	51 Years
Median	51 Years
Min-Max	37-62 Years
Number of implants	
2 implant	7 (19.4)
3 implants	15 (41.7)
≥5 implants	3 (8.4)
Mean ± SD	3.3±0.91 implants
Duration of implants	
≤ 12 months	8 (22.2)
13-24 months	22 (61.1)
≥25 months	6 (16.7)
Mean ± SD	17.8±6.5 months

In the current study *S. aureus,* Coagulase-negative, *H. influenza, H. parainfluenzae, E. coli, K. pneumoniae, Citrobacter freundii*, and *P. aeruginosa* were colonized the oral cavity of implant patients. *S. aureus* colonization was higher in implant patients (5.6% in the palate) compared to 2.8% in those without implants in the palate. While implant patients had a lower rate of Coagulase-negative colonization (8.3% in the palate), persons without implants had a greater frequency of Coagulase (22.2%). There was a higher colonization rate in implant patients equivalent to 83.3% in palate versus, a lower rate (75%) in individuals without implants in viridians (apathy) Streptococcus, including *S. mutans*. Additionally, potentially harmful Enterobacteriaceae spp bacteria colonized implant patients slightly more than non-implant patients (Table 2). In current study it was observed that a low level of oxacillin resistance (5.1%) in *S. mutans* isolates. However, in current investigation, we found that the isolates of *S. mutans* had a substantial level of tetracycline resistance (55.93%), 11.9% for co-trimoxazole, 10.2% for erythromycin, and just 1.7% for clindamycin. The antibiotic sensitivity results are presented in Table 3 to Table 8.

DISCUSSION

Both main and secondary colonizers of the microbiota can have an impact on the peri-implant's health. Early bacterial colonization in a healthy implant site takes about 6 months to reach a stage where it resembles the microbiome of the remaining natural dentition in the arch and varies depending on the condition of the normal dentition[6,9]. Additionally, according to the literature, when the sulcus depth was less than 4 mm from an implant-abutment junction, the peri-implant sulci's microbiota resembled that of tooth sulci[9].

Table 2: Isolation frequency (%) of bacteria in hard palate and tongue dorsa of dental implant patients and health normal subjects.

Bacteria	Implants patients N=36		Healthy subject N=36		Total isolates
	Palate N (%)	Tongue N (%)	Palate	Tongue	
S. aureus	2 (5.6)	2 (5.6)	1 (2.8)	3 (8.3)	8
Coagulase-negative	3 (8.3)	4 (11.1)	8 (22.2)	17 (47.2)	32
Streptococci					
S. pyogens	1 (2.8)	0 (0.0)	1 (2.8)	0 (0.0)	2
S.mitior	2 (5.6)	7 (19.4)	9 (25)	5 (13.9)	23
S. sanguis	5 (13.9)	8 (22.2)	8 (22.2)	5 (13.9)	26
S.mutans	30 (83.3)	29 (80.6)	27(75)	25(69.4)	111
S. alivarius	9 (25)	8 (22.2)	9 (25)	5(13.9)	31
S. milleri	1 (2.8)	1 (2.8)	1(2.8)	4 (11.1)	7
Neisseria spp.	19 (52.8)	21 (58.3)	24(66.7)	28(77.8)	92
Haemophilus influenza	1 (2.8)	0 (0.0)	0 (0.0)	0 (0.0)	1
H. parainfluenzae	2 (5.6)	2 (5.6)	7 (19.4)	6(16.7)	17
Enterobacteriaceae spp.					
Escherichia coli	2 (5.6)	3 (8.3)	1 (2.8)	1 (2.8)	7
Klebsiella pneumoniae	1 (2.8)	2 (5.6)	1 (2.8)	1 (2.8)	5
Morganella morganii	0 (0)	0 (0)	0 (0)	1 (2.8)	1
Citrobacter freundii	1 (2.8)	1 (2.8)	0 (0)	0 (0)	2
Pseudomonas aeruginosa	1 (2.8)	2 (5.6)	0 (0.0)	0 (0.0)	3

Table 3: Antibiotic patterns of *S. aureus* isolated from hard palate and tongue dorsa of implant and normal healthy subjects, N=8 isolates.

Antibiotic name	Dental implant N=4		Normal healthy subjects N=4	
	Resistance N (%)	Sensitive N (%)	Resistance N (%)	Sensitive N (%)
Tetracycline	3 (75)	1 (25)	2 (50)	2 (50)
Erythromycin	3 (75)	1 (25)	2 (50)	2 (50)
Co-trimoxazole	2 (50)	2 (50)	1 (25)	3 (75)
Amoxicillin-Clavulanic acid	1 (25)	3 (75)	1 (25)	3 (75)
Gentamicin	1 (25)	3 (75)	0 (0.0)	4 (100)
Oxacillin	1 (25)	3 (75)	1 (25)	3 (75)
Ciprofloxacin	0 (0.0)	4 (100)	0 (0.0)	4 (100)
Cloxacillin	1 (25)	3 (75)	1 (25)	3 (75)
Cefoxtine	0 (0.0)	4 (100)	0 (0.0)	4 (100)
Amikacin	0 (0.0)	4 (100)	0 (0.0)	4 (100)
Clindamycin	0 (0.0)	4 (100)	0 (0.0)	4 (100)
Vancomycin	0 (0.0)	4 (100)	0 (0.0)	4 (100)

The microbiota surrounding problematic implants, however, varied depending on the infection stage[20-22]. In the current study *S. aureus*, *Coagulase-negative*, *Haemophilus influenza*, *H. parainfluenzae*, *E. coli K. pneumoniae*, *Citrobacter freundii*, and *P. aeruginosa* were colonized the oral cavity of implant patients making biofilm. Adhesion, growth, maturation, and dispersion are the stages in the formation of biofilm by the colonization of microorganisms9,[23]. Electrostatic attraction leads to the first adherence of bacteria to a surface, which is followed by the production of extracellular polymers[24]. A mechanical adhesion of the bacteria is also encouraged by the host's rough surface through mechanical retention[6,9].

Specific signaling molecules are required for the co-aggregation of bacteria, which determines which bacterial species may adhere in the colony-forming unit. Through the production of a biomarker that either facilitates or hinders the creation of biofilms, bacterial aggregation causes an inflammatory response in the host tissue. However, the biofilm becomes resistant to antimicrobial therapy as it matures and produces extracellular polymers[25,26]. The development of biofilms and peri-implant infection are aided by the interaction between bacteria and the inflammatory response of the host.

Table 4: Antibiotic patterns of coagulase-negative *Staphylococcus* isolated from hard palate and tongue dorsa of implant and normal healthy subjects, N=32 isolates.

Antibiotic name	Dental implant N=7		Normal healthy subjects N=25	
	Resistance N (%)	Sensitive N (%)	Resistance N (%)	Sensitive N (%)
Tetracycline	6 (85.7)	1 (14.3)	15 (60)	10 (40)
Erythromycin	5 (71.4)	2 (28.6)	7 (28)	18 (72)
Co-trimoxazole	3 (42.9)	4 (57.1)	6 (24)	19 (76)
Amoxicillin-Clavulanic acid	2 (28.6)	5 (71.4)	9 (36)	16 (64)
Gentamicin	2 (28.6)	5 (71.4)	3 (12)	22 (88)
Oxacillin	1 (14.3)	6 (85.7)	4 (16)	21 (84)
Ciprofloxacin	1 (14.3)	6 (85.7)	2 (8)	23 (92)
Cloxacillin	1 (14.3)	6 (85.7)	1 (4)	24 (96)
Cefoxtine	2 (28.6)	5 (71.4)	1(4)	24 (96)
Amikacin	0(0.0)	7 (100)	0(0.0)	25 (100)
Clindamycin	0(0.0)	7 (100)	0(0.0)	25 (100)
Vancomycin	0 (0.0)	7 (100)	0(0.0)	25 (100)

Understanding the cellular mechanisms behind biofilm formation will help to block the bacterial adhesion and proliferation that precede biofilm formation. In the current study, implanted patients had a low rate of *S. aureus* colonization (5.6% in the palate) compared to 2.8% in non-implanted persons. The current study results differ from those of Al-Shami *et al.*[1,11], who found that the rate of bacterial isolates from the palate, back, tongue, and dental plaque smears was higher in denture wearers than in natural teeth patients (11.5% versus 1.6% in the palate). While there was a lower incidence of Coagulase-negative colonization in implanted patients (11.1% in the tongue) and a higher incidence of Coagulase-negative (47.2%) in subjects without implanted teeth in the current study, Al-Shami *et al.*,[1,11] found a lower incidence of Coagulase-negative colonization in denture patients (16.4% in the tongue) and a higher incidence of Coagulase-negative (47.5%) in subjects without dentures.

There was a greater colonization rate of viridians (apathy) *Streptococcus*, including *S. mutans*, in the implanted group in the palate, compared to people with

healthy teeth (69.4%). The findings of the current study are consistent with those of earlier studies in that there are many microbial compositional similarities between the populations of adults wearing full or partial dentures and adults with intact teeth, as well as some notable compositional differences[1,11,27]. Recent research have studied dentures in the adult population wearing full or partial dentures and individuals with natural teeth as well as factors affecting oral microbia in Yemen[1,11,27,28]. Numerous articles have solely addressed *Candida*[27-31]. However, researchers of current study were unaware of any published study that addresses the colonization of potentially harmful aerobic bacteria in implanted individuals. Currently, there aren't many studies on dental microbiology and the factors influencing their variety and quantity, though most of them focused on anaerobic bacteria[9].

Table 5: Antibiotic patterns of *S. mutans* isolated from hard palate and tongue dorsa of implant and normal healthy subjects, N=111 isolates.

	Dental implant N=59		Normal healthy subjects N=52	
Antibiotic name	**Resistance N (%)**	**Sensitive N (%)**	**Resistance N (%)**	**Sensitive N (%)**
Tetracycline	33 (55.9)	26 (44.1)	23 (44.2)	29 (55.8)
Erythromycin	6 (10.2)	53 (89.8)	3 (5.7)	49 (94.2)
Co-trimoxazole	7 (11.9)	52 (88.1)	7 (13.5)	98 (86.5)
Amoxicillin-Clavulanic acid	6 (10.2)	53 (89.8)	5 (9.6)	47 (90.4)
Gentamicin	4 (6.8)	55 (93.2)	5 (9.6)	47 (90.4)
Oxacillin	3 (5.1)	56 (94.9)	2 (3.8)	50 (96.2)
Ciprofloxacin	2 (3.4)	107 (96.9)	5 (9.6)	47 (90.4)
Cloxacillin	1 (1.7)	58 (98.3)	3 (5.7)	49 (94.2)
Cefoxtine	2 (3.4)	107 (96.9)	3 (5.7)	49 (94.2)
Amikacin	0 (0.0)	59 (100)	0 (0.0)	52 (100)
Clindamycin	1 (1.7)	58 (98.3)	0 (0.0)	52 (100)
Vancomycin	0 (0.0)	59 (100)	0 (0.0)	52 (100)

In one such study, the analysis of the microbiota in failing or failed implants revealed significantly elevated levels of *Prevotella intermedia, Capnocytophaga* spp, *Porphyromonas gingivalis*, *Peptostreptococcus micros*, *Fusobacterium* spp, *Campylobacter rectus*, *Actinomycetemcomitans*, *Treponema denticola* and *Candida albicans*[9,32].

In the current study, potentially pathogenic *Enterobacteriaceae* spp bacteria were more colonized in implanted patients than in individuals with normal teeth: for example, *E. coli* (8.3% in implanted versus 2.8% in the absence of implants) and *P. aeruginosa* (5.6% in implanted versus 0.0% in the absence of implants).

Table 6: Antibiotic patterns of *S. mitior* isolated from hard palate and tongue dorsa of implant and normal healthy subjects, N=23 isolates.

	Dental implant N=9		Normal healthy subjects N=14	
Antibiotic name	**Resistance N (%)**	**Sensitive N (%)**	**Resistance N (%)**	**Sensitive N (%)**
Tetracycline	5 (55.6)	4 (44.4)	6 (42.9)	8 (57.1)
Erythromycin	1 (11.1)	8 (88.9)	1 (7.1)	13 (92.9)
Co-trimoxazole	2 (22.2)	7 (77.8)	2 (14.3)	12 (85.7)
Amoxicillin-Clavulanic acid	1 (11.1)	8 (88.9)	5 (10.6)	42 (89.4)
Gentamicin	1 (11.1)	8 (88.9)	1 (7.1)	13 (92.9)
Oxacillin	0 (0.0)	9 (100)	0 (0.0)	14 (100)
Ciprofloxacin	0 (0.0)	9 (100)	0 (0.0)	14 (100)
Cloxacillin	0 (0.0)	9 (100)	0 (0.0)	14 (100)
Cefoxtine	0 (0.0)	9 (100)	0 (0.0)	14 (100)
Amikacin	0 (0.0)	9 (100)	0 (0.0)	14 (100)
Clindamycin	0 (0.0)	9 (100)	0 (0.0)	14 (100)
Vancomycin	0 (0.0)	9 (100)	0 (0.0)	14 (100)

The implants (implant palague) of current investigated patients had been colonized by a variety of possible respiratory infections, with *S. aureus* accounting for 5.6% of these. Table 2 lists the remaining probable respiratory pathogens as follows: *P. aeruginosa* (5.6%), *K. pneumoniae* (5.6%), *H. influenzae* (2.8%), and *H. parainfluenzae* (5.6%). Reservoirs for possible respiratory infections can be found in dental plaque and the tongue dorsa. According to Sumi *et al*., dental prosthesis plaque may act as a reservoir for potential pathogens to help colonization in the oropharynx, and poor dental prosthesis hygiene is a significant factor in increasing oropharyngeal bacterial colonization. It has been proposed that the surface of the tongue may serve as an additional and likely more consistent, reservoir of respiratory pathogens[6,9,33]. In both implanted patients

and healthy people, respiratory pathogens such as *S. aureus*, *Haemophilus influenzae*, *H. parainfluenzae*, and *Neisseria* species were isolated. Obtained result is similar to that reported by Tyrrell *et al*., Sumi *et al*., Goldberg *et al.*, and Senpuku *et al*., where some uncommon microorganisms are found in oral microbiota[34-36]. Dental professionals often prescribe the majority of the antibiotics utilized in this study[1,9].

Although resistant bacteria can also develop in healthy individuals who have not recently received antibiotic treatment, the frequency of *streptococci* resistant to oral medication is higher in those who are frequently exposed to antibiotics[13].

In regular dentistry practice, β-lactam antibiotics are the most frequently utilized chemo preventive agents. However, oral *streptococci* are becoming more resistant to penicillin[1,10,11]. Although these bacteria can be found in healthy patients who have not recently received antimicrobial treatment, the prevalence of resistant oral *streptococci* is higher in those who get antibiotics on a regular basis[1].

Table 7: Antibiotic patterns of *S. sanguis* isolated from hard palate and tongue dorsa of implant and normal healthy subjects, N=26 isolates.

	Dental implant N=13		Normal healthy subjects N=13	
Antibiotic name	**Resistance N (%)**	**Sensitive N (%)**	**Resistance N (%)**	**Sensitive N (%)**
Tetracycline	6 (46.2)	7 (53.8)	5 (38.5)	8(61.5)
Erythromycin	1 (7.7)	12 (92.3)	2 (15.4)	11 (84.6)
Co-trimoxazole	2 (15.4)	11 (84.6)	2 (15.4)	11 (84.6)
Amoxicillin-Clavulanic acid	1 (7.7)	12 (92.3)	1 (7.7)	12 (92.3)
Gentamicin	0 (0.0)	13 (100)	0 (0.0)	13 (100)
Oxacillin	0 (0.0)	13 (100)	0 (0.0)	13 (100)
Ciprofloxacin	0 (0.0)	13 (100)	0 (0.0)	13 (100)
Cloxacillin	1 (7.7)	12 (92.3)	1 (7.7)	12 (92.3)
Cefoxtine	1 (7.7)	12 (92.3)	0 (0.0)	13 (100)
Amikacin	1 (7.7)	12 (92.3)	0 (0.0)	13 (100)
Clindamycin	0 (0.0)	13 (100)	0 (0.0)	13 (100)
Vancomycin	0 (0.0)	13 (100)	0 (0.0)	13 (100)

Table 8: Antibiotic patterns of *S. alivarius* isolated from hard palate and tongue dorsa of implant and normal healthy subjects, N=31 isolates.

	Dental implant N=17		Normal healthy subjects N=14	
Antibiotic name	**Resistance N (%)**	**Sensitive N (%)**	**Resistance N (%)**	**Sensitive N (%)**
Tetracycline	9 (52.9)	8 (47.1)	8 (57.1)	6 (42.9)
Erythromycin	3 (17.6)	14 (82.4)	3 (21.4)	11 (78.6)
Co-trimoxazole	3 (17.6)	14 (82.4)	3 (21.4)	11 (78.6)
Amoxicillin-Clavulanic acid	2 (11.8)	44 (83)	1 (7.1)	13 (92.9)
Gentamicin	1 (5.9)	16 (94.1)	1 (7.1)	13 (92.9)
Oxacillin	1 (5.9)	16 (94.1)	1 (7.1)	13 (92.9)
Ciprofloxacin	0 (0.0)	17 (100)	0 (0.0)	17 (100)
Cloxacillin	0 (0.0)	17 (100)	0 (0.0)	17 (100)
Cefoxtine	0 (0.0)	17 (100)	0 (0.0)	17 (100)
Amikacin	0 (0.0)	17 (100)	0 (0.0)	17 (100)
Clindamycin	0 (0.0)	17 (100)	0 (0.0)	17 (100)
Vancomycin	0 (0.0)	17 (100)	0 (0.0)	17 (100)

Bacterial resistance to antibiotics such as penicillin and other β-lactams is a major public health concern in many parts of the world. In current study it was observed a low level of oxacillin resistance (5.1%) in *S. mutans* isolates. The low prevalence of resistance to penicillin group in *S. mutans* in current study is different from that previously observed in Yemen (14.9%)[10] and (11.6%)[11] resistance, South Africa and Spain in oral *S. viridians*[1,9]. Penicillin resistance genes can be transmitted between related species, according to a number of *in-vitro* investigations[1,9]. The development and spread of penicillin resistance in oral *streptococci* may be significantly influenced by these mechanisms as well as selective antibiotic pressure.

In addition, a considerable level of penicillin resistance was found by Pasquantonio *et al*.,[37].

Out of 50 isolates of *S. mutans*, 14% were penicillin-resistant, representing 13.4% of 550 oral streptococcal clinical isolates. However, the rate of full resistance to penicillin and ampicillin among *S. mutans* isolates in a research by Dhamodhar *et al*.,[38] done in 2014 was higher than current obtained data. The American Heart Association recommends antimicrobial prophylaxis one hour before to dental surgery for high-risk cardiovascular patients, such as amoxicillin (2 g) as first choice and clindamycin (600 mg) as a second choice[1,11]. However, production of *β*-lactamase is infrequent for most *streptococci*, where resistance is

caused by slightly changed penicillin binding proteins[1,9,10]. However, in current investigation, it was found that the isolates of *S. mutans* had a substantial level of tetracycline resistance (55.93%), 11.9% for co-trimoxazole, 10.2% for erythromycin, and just 1.7% for clindamycin. As a result, the first drug of choice in this case should be clindamycin, whose resistance rate is 1.7%. In the end, *S. mutans*' evolved resistance is unknown. The present study's updated information on antibiotic susceptibility testing aids in informing pharmaceutical companies to develop new methods for efficient prophylaxis against dental infections. This outcome also provides the dentist in Yemen with the best option for prescribing a suitable antibiotic.

Limitations of the study

In the world and Yemen, no sufficient study has been undertaken to verify the composition of aerobic bacteria in the oral cavity of implant patients and compare them to those with natural teeth. A prospective study with a larger number of patients, anaerobic species, and other antibiotics tested for common isolates is required to investigate the effect of implants on bacterial colonization of the oral cavity as well as its effect on antibiotic susceptibility patterns.

CONCLUSIONS

The study found an increased rate of pathogenic bacteria such as *S. aureus* and *Enterobacteriaceae* spp such as *E. coli*, *K. pneumoniae*, and *P. aeruginosa* in implant patients, while there was a higher colonization rate of *S. viridians* including *S. mutans* in implant patients compared to a moderate rate in individuals with normal teeth. Also, the study demonstrates significant levels of antibiotics resistance in *S. aureus*, CoNs and *S. viridians* oral isolates in both groups (implant group and normal group). Further study is required to include more penicillin group and cephalosporin group and know the minimum inhibitory concentration of *β*-lactam and non *β*-lactam antibiotics towards *S. viridians* group.

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AUTHOR'S CONTRIBUTIONS

Al-Shamahy HA: writing original draft, review and editing, data curation. **Al-Hamzi MA:** methodology, investigation. **Sharafuddin AH:** editing, review. **Al-Shameri BHH:** formal analysis, supervision. **AL-Haddad KA:** methodology, data curation. **Al-Najhi MA:** writing, formal analysis. **Al-Moyed KA:** writing, review. All authors revised the article and approved the final version.

DATA AVAILABILITY

The datasets generated during this study are available from the corresponding author upon reasonable request.

CONFLICT OF INTEREST

There are no competing interests involved in this work.

REFERENCES

1. Al-Shami IZ, Alrubaidi YAS, Al-Shamahy HA, *et al*. Effect of removable dentures on colonization of aerobic bacteria in the oral cavity and antibiotic pattern of the common isolated bacteria. Universal J Pharm Res 2022; 7(6):1-8. *https://doi.org/10.22270/ujpr.v7i6.833*
2. Schwiertz A. Microbiota of the Human Body: Implications in health and disease. Preface. Adv Exp Med Biol 2016; 902:v. *PMID: 27532080*
3. Sherwood L, Willey J, Woolverton C. Prescott's Microbiology (9th ed.). New York: McGraw Hill 2013. 713-721. ISBN 9780073402406. OCLC 886600661.
4. Richard J. Lamont, George Hajishengallis, Howard F. Jenkinson. Oral microbiology and immunology (2nd ed.). Washington, DC: ASM Press 2014. ISBN 978-1-55581-673-5. OCLC 840878148.
5. Noble JM, Scarmeas N, Papapanou PN. Poor oral health as a chronic, potentially modifiable dementia risk factor: review of the literature. Current Neurol Neurosci Rep 2013; 13 (10): 384. *https://doi.org/10.1007/s11910-013-0384-x*
6. Sharafuddin AH, Alshameri BH, AL-Haddad KA, Al-Najhi MMA, Al-Shamahy HA. The effect of dental implants on increasing the colonization rate of aerobic bacteria in the oral cavity. Universal J Pharm Res 2023; 8(3):28-33. *https://doi.org/10.22270/ujpr.v8i3.944*
7. Misch CE. Misch's Contemporary Implant Dentistry. St.Louis, Missouri: Mosby Elsevier, [4th ed.] 0323391559, 9780323391559. Retrieve 6/20/2023.
8. Elani HW, Starr JR, Da Silva JD, Gallucci GO. Trends in Dental Implant Use in the U.S., 1999-2016, and Projections to 2026. J Dental Res 2018; 97 (13): 1424–1430. *https://doi.org/10.1177/0022034518792567*
9. Banu Raza F, Vijayaragavalu S, Kandasamy R, Krishnaswami V, Kumar VA. Microbiome and the inflammatory pathway in peri-implant health and disease with an updated review on treatment strategies. J Oral Biol Craniofac Res 2023 Mar-Apr; 13(2):84-91. *https://orcid.org/10.1016/j.jobcr.2022.11.005*
10. Alhasani AH, Ishag RA, Al-Akwa AAY, Al-Shamahy HA, Al-labani MAA. Association between the *Streptococcus mutans* biofilm formation and dental caries experience and antibiotics resistance in adult females. Universal J Pharm Res 2021; 5(6):1-6. *https://orcid.org/10.22270/ujpr.v5i6.507*
11. Al-Shami HZ, Al-Haimi MA, Al-Shamahy HA, *et al*. Patterns of antimicrobial resistance among major bacterial pathogens isolated from clinical samples in two tertiary's hospitals, in Sana'a, Yemen. Universal J Pharm Res 2021; 6(5):60-67. *https://doi.org/10.22270/ujpr.v6i5.674*
12. WHO. Antimicrobial resistance: global report on surveillance 2014. WHO. WHO. Archived from the original on 15 May 2015. Retrieved 19 September 2022.
13. Dadgostar P. Antimicrobial Resistance: Implications and Costs. Infect Drug Resis 2019; 12: 3903–3910. *https://doi.org/10.2147/IDR.S234610*
14. CDC. The biggest antibiotic-resistant threats in the U.S." Centers for Disease Control and Prevention. 6 November 2019. Retrieved 19 September 2022.
15. Samuel S. Our antibiotics are becoming useless. Vox 2019. Retrieved 29 September 2022.
16. O'Brien TF, Clark A, Peters R, Stelling J. Why surveillance of antimicrobial resistance needs to be automated and comprehensive. J Glob Antimicrob Resist 2019 Jun; 17:8-15. *https://doi.org/10.1016/j.jgar.2018.10.011*
17. Cheesbrough M. District laboratory practice in tropical countries. Cambridge: Cambridge University Press; 2010. *https://doi.org/10.1017/CBO9780511581304*
18. Church DL. Biochemical tests for the identification of aerobic bacteria. Clinical Microbiology Procedures,

Handbook. 4th ed. Washington, DC: American Society of Microbiology; 2016:3-17.
19. Wayne PA. Performance Standards for Antimicrobial Disc Susceptibility Testing. 30th edition, National Committee for Clinical Laboratory Standards; 2022.
20. Derks J, Tomasi C. Peri-implant health and disease. A systematic review of current epidemiology. J Clin Periodontol 2015 Apr; 42:S158–S171. *https://doi.org/10.1111/jcpe.12334*
21. Marrone A, Lasserre J, Bercy P, Brecx MC. Prevalence and risk factors for peri-implant disease in Belgian adults. Clin Oral Implants Res 2013 Aug; 24(8):934–940. *https://doi.org/10.1111/j.1600-0501.2012.02476.x*
22. Zetterqvist L, Feldman S, Rotter B, *et al*. A prospective, multicenter, randomized-controlled 5-year study of hybrid and fully etched implants for the incidence of peri-implantitis. J Periodontol 2010 Apr; 81(4):493–501. *https://doi.org/10.1902/jop.2009.090492*
23. Raffaini FC, Freitas AR, Silva TSO, *et al*. Genome analysis and clinical implications of the bacterial communities in early biofilm formation on dental implants restored with titanium or zirconia abutments. Biofouling 2018 Feb 7; 34(2):173–182. *https://doi.org/10.1080/08927014.2017.1417396*
24. Stokman MA, van Winkelhoff AJ, Vissink A, Spijkervet FKL, Raghoebar GM. Bacterial colonization of the peri-implant sulcus in dentate patients: A prospective observational study. Clin Oral Invest 2017 Mar 24; 21(2):717–724. *https://doi.org/10.1007/s00784-016-1941-x*
25. Dabdoub SM, Tsigarida AA, Kumar PS. Patient-specific analysis of periodontal and peri-implant microbiomes. J Dent Res 2013 Dec 24; 92(12_suppl):168S–175S. *https://doi.org/10.1177/0022034513504950*
26. Renvert S, Roos-Jansåker A-M, Lindahl C, Renvert H, Rutger Persson G. Infection at titanium implants with or without a clinical diagnosis of inflammation. Clin Oral Implants Res 2007 Aug; 18(4):509–516. *https://doi.org/10.1111/j.1600-0501.2007.01378.x*
27. Al-Kebsi AM, Othman AM, Al-Shamahy HA, *et al*. Oral C. albicans colonization and non-candida albicans candida colonization among University students, Yemen. Universal J Pharm Res 2017; 2(5): 5-9. *https://orcid.org/10.22270/ujpr.v2i5.R2*
28. Alhasani AH, Al-Akwa AAY, Al-Shamahy HA, *et al*. Biofilm formation and antifungal susceptibility of Candida isolates from oral cavity after the introduction of fixed orthodontic appliances. Universal J Pharm Res 2020; 5(4):1-8. *https://orcid.org/10.22270/ujpr.v5i4.435*
29. Al-deen HMS, Obeyah AA, Al-Shamahy HA, *et al*. Oral Candida albicans colonization rate in fixed orthodontics patients. Universal J Pharm Res 2020;5(2):1-6. *https://orcid.org/10.22270/ujpr.v5i2.380*
30. Al-Sanabani NF, Al-Kebsi AM, Al-Shamahy HA, Abbas MA. Etiology and risk factors of stomatitis among Yemeni denture wearers. Universal J Pharm Res 2018; 3(1):1-5. *https://orcid.org/10.22270/ujpr.v3i1.R9*
31. Al-Haddad KA, Al-dossary OAE, Al-Shamahy HA. Prevalence and associated factors of oral non-candida albicans candida carriage in denture wearers in Sana'a city-Yemen. Universal J Pharm Res 2018; 3(4):1-6. *https://doi.org/10.22270/ujpr.v3i4.176*
32. Ghensi P, Manghi P, Zolfo M, *et al*. Strong oral plaque microbiome signatures for dental implant diseases identified by strain-resolution metagenomics. NPJ Biofilms Microbiomes 2020 Dec 30;6(1):47. 22. *https://doi.org/10.1038/s41522-020-00155-7*
33. Sumi Y, Miura H, Nagaya M, Michiwaki Y, Uematsu H. Colonisation on the tongue surface by respiratory pathogens in residents of a nursing home--A pilot study. Gerodontol 2006 Mar; 23(1):55-9. *https://doi.org/10.1111/j.1741-2358.2006.00093.x*
34. Tyrrell KL, Citron DM, Warren YA, Nachnani S, Goldstein EJ. Anaerobic bacteria cultured from the tongue dorsum of subjects with oral malodor. Anaerobe 2003; 9(5):243-6. *https://doi.org/10.1016/S1075-9964(03)00109-4*
35. Goldberg S, Cardash H, Browning H 3rd, Sahly H, Rosenberg M. Isolation of Enterobacteriaceae from the mouth and potential association with malodor. J Dent Res 1997 Nov;76(11):1770-5. *https://doi.org/10.1177/00220345970760110801*
36. Senpuku H, Sogame A, Inoshita E, Tsuha Y, Miyazaki H, Hanada N. Systemic diseases in association with microbial species in oral biofilm from elderly requiring care. Gerontol 2003 Sep-Oct; 49(5):301-9. *https://doi.org/10.1159/000071711*
37. Pasquantonio G, Condò S, Cerroni L, Bikiqu L, Nicoletti M, Prenna M, Ripa S. Antibacterial activity of various antibiotics against oral streptococci isolated in the oral cavity. Int J Immunopathol Pharmacol 2012 Jul-Sep; 25(3):8059. *https://doi.org/10.1177/039463201202500331*
38. Dhamodhar P, Sreenivasa Murthy, Channarayappa, Shanthakumar SS, Indiresha HN. Prevalence, characterization and heterogeneity studies on *Streptococcus mutans* isolated from Bangalore urban population. Int J Pharm Bio Sci 2014; 5(3): 122-128.