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CLINICAL RESEARCH

Viral contamination of acrylic resin removable denture bases in patients with COVID-19: A cross-sectional study

Nadia Elyassi Gorji, DDS,[a] Negareh Salehabadi, DDS,[b] Zakaria Zakariaei, MD, PhD,[c] Jamshid Yazdani Cherati, PhD,[d] Leila Delavaryan, BS,[e] and Mohammad Ebrahimi Saravi, DDS, PhD[f]

ABSTRACT

Statement of problem. Salivary gland ducts are one of the primary targets of severe acute respiratory syndrome coronavirus 2. Moreover, saliva contains minor and major salivary gland secretions and a combination of nasopharyngeal and lung secretions. The acrylic resin bases of complete or partial removable dentures have pores and provide a favorable environment for the growth of microorganisms.

Purpose. The purpose of this cross-sectional study was to investigate the presence of viral contamination of acrylic resin removable denture bases in patients with coronavirus disease 2019 (COVID-19).

Material and methods. The acrylic resin denture bases (partial and complete) of 29 patients with COVID-19 who underwent treatment in the Infectious Diseases Department of Razi Hospital in Ghaemshahr, Mazandaran, Iran, were evaluated. Samples were collected from the intaglio surface of the prostheses by direct swabbing and coding and were evaluated in a laboratory for the presence or absence of coronavirus. The relationship between hospital polymerase chain reaction (PCR) and denture PCR and the relationship between denture type and denture PCR were evaluated with the Fisher exact test (α=.05).

Results. Twenty-nine patients, age range 55 to 85 years, 18 women, 3 with partial dentures and 26 with complete dentures, were evaluated. The hospital PCR test was positive in 28 patients, while the denture PCR test was positive in 4 patients. No significant relationship was observed between the results of hospital PCR and denture PCR in patients with COVID-19 (P=.138). All 4 patients who tested positive for denture PCR had complete dentures. No significant relationship was found between denture type and denture PCR test results in patients with COVID-19 (P=1.000).

Conclusions. Despite the microporous structure of the acrylic resin base, no statistically significant viral contamination was observed. (J Prosthet Dent 2021;■:■-■)

The coronavirus of the *Coronaviridae* family has a long, single, plus-stranded ribonucleic acid (RNA)[1] and is one of the major pathogens primarily targeting the human respiratory system. The previous outbreak of the virus, known as severe acute respiratory syndrome coronavirus (SARS-CoV), first occurred in 2002, and the Middle East respiratory syndrome coronavirus (MERS-CoV) first appeared in 2012. In late December 2019, in Wuhan, China, a group of patients were sent to the hospital with an initial diagnosis of pneumonia of unknown etiology,[2,3] which, after spreading to other countries, was designated as a pandemic by the World Health Organization.[4]

Since the salivary gland ducts are among the primary targets of SARS-CoV, they have been considered a potential source for this virus.[5] The presence of COVID-19 in patients' saliva also suggests the possibility of infection of the salivary glands with this virus.[6] Despite the production of antibodies against the surface and internal proteins of RNA, the SARS-CoV-2 virus can be present in the posterior

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[a]Predoctoral student, Student Research Committee, Faculty of Dentistry, Mazandaran University of Medical Sciences, Sari, Iran.
[b]Predoctoral student, Student Research Committee, Faculty of Dentistry, Mazandaran University of Medical Sciences, Sari, Iran.
[c]Assistant Professor, Toxicology and Forensic Medicine Devition, Orthopedic Research Center, Imam Khomeini Hospital, Mazandaran University of Medical Science, Sari, Iran.
[d]Professor, Department of Biostatistics, Health Sciences Research Center, Addiction Institute, Faculty of Health, Mazandaran University of Medical Sciences, Sari, Iran.
[e]Nurse, Department of Infectious Diseases, Antimicrobial Resistance Research Center, Razi Hospital, Qaemshahr, Iran.
[f]Assistant Professor, Department of Prosthodontics, Faculty of Dentistry, Mazandaran University of Medical Sciences, Sari, Iran; and Assistant professor, Dental Research Committee, Faculty of Dentistry, Mazandaran University of Medical Sciences, Sari, Iran.

Clinical Implications

Testing removable dentures is not a suitable method for diagnosing COVID-19 in clinical practice.

oropharyngeal saliva samples of one-third of patients for 20 days or more. In most patients, the peak antibody response to the virus has a positive correlation with age and can last 10 days or more from the onset of symptoms.[7] Meanwhile, saliva contains not only the secretions of the minor and major salivary glands but also a combination of nasopharyngeal and lung secretions that come to the throat with the movement of the respiratory cilia,[6] making saliva droplets the primary source of infection.[8]

Removable dentures made with porous materials provide a favorable environment for the growth of microorganisms.[9,10] Therefore, the aim of this study was to investigate the presence of viral contamination on acrylic resin removable denture bases in patients with COVID-19. The research hypothesis was that the COVID-19 virus would be detected on the intaglio surface of dentures in patients diagnosed with COVID-19.

MATERIAL AND METHODS

The present cross-sectional (descriptive-analytical) study, with the ethics code of IR.MAZUMS.REC.1399.605, was conducted from January to March 2021. The acrylic resin denture bases (partial and complete) of 29 patients (aged 55 to 85 years) were included in the study by census sampling. Each patient diagnosed with COVID-19 had removable dentures during the illness and underwent treatment during the study period in the Infectious Diseases Department of Razi Hospital in Ghaemshahr, Mazandaran, Iran. The sample size was determined from the 24 patients in the study by Przybyłowska et al[10] and by using the following equation:

$$n=\frac{\left(z_{\frac{\alpha}{2}}+z_{\beta}\right)^2 P(1-P)}{(P-P_0)^2}=24, P=.75, P_0=.5, \alpha=.05, \beta=.2$$

Inclusion criteria were being hospitalized in the COVID-19 ward with a definitive diagnosis and having a removable denture. Patients lacking polymerase chain reaction (PCR) tests or admitted to the intensive care unit were excluded from the research. The patients entered the study voluntarily, and written informed consent was obtained from them by nurses after providing explanations. The participants were also instructed to refrain from eating, drinking, or chewing gum for 30 minutes before sampling.

Samples were taken from the intaglio surface of the denture by the head nurse of the infectious diseases department of the hospital (L.D.). The direct swabbing method was used because the virus was considered more likely to attach and accumulate on the unpolished intaglio surface that is in direct contact with the salivary accessory glands of the palate. The samples were obtained between 10 AM and 12 noon, were coded to be separated from each other, and were sent to a laboratory to be evaluated for the presence or absence of coronavirus. Subsequently, the swab samples were removed from the transfer medium, and, after RNA extraction, 2 virus genes were identified simultaneously with the real-time PCR reaction. The data were statistically analyzed with a statistical software program (IBM SPSS Statistics, v25; IBM Corp) with the Fisher exact test. The relationship between hospital PCR and denture PCR and the relationship between denture type and denture PCR were evaluated by the Fisher exact test (α=.05).

Real-time reverse transcription PCR is the standard molecular approach for COVID-19 diagnosis.[11] The number of amplification cycles needed for the target gene to reach a threshold level is represented by real-time CR cycle threshold (Ct) values. Ct values are thus inversely related to viral load and can be used as a proxy for quantifying the viral RNA copy number in a sample; however, the use of Ct values as a proxy for viral load is affected by the assay itself (Correlation will fall within the linear dynamic range of the particular RT-PCR assay used.) and factors within the sample matrix that can affect amplification efficiency.[12] Patients with a Ct of less than 28.0 had a higher viral load and, based on viral antigen expression, were possibly still replicating the virus[13]; the higher the Ct values, the lower the severity of the infection.

RESULTS

The study population consisted of 29 patients with COVID-19 aged 55 to 85 years, 18 (62.1%) women and 11 (37.9%) men, 3 (10.3%) with partial dentures and 26 (89.7%) with complete dentures. One participant had a negative hospital PCR result, and 28 participants had a positive hospital PCR result. In comparison, the PCR test results from the dentures were negative in 25 participants and positive in 4 participants, including the participant with a negative hospital PCR test. The results of the hospital PCR and the denture PCR are cross-tabulated in Table 1. Based on the results of the Fisher exact test, no significant relationship was observed between the hospital PCR test and the denture PCR test results (P=.138).

All 3 participants with a partial denture had a negative denture PCR test, and, of the 26 with a complete denture, 22 had a negative denture PCR test result and 4 had a positive result (Table 2). The Fisher exact test showed no

Table 1. Cross-tabulation of hospital PCR test and denture PCR test

	Denture PCR			
Hospital PCR	**Negative, N (%)**	**Positive, N (%)**	**Total, N (%)**	***P***
Negative, N (%)	0 (0.0)	1 (3.4)	1 (3.4)	.138
Positive, N (%)	25 (86.2)	3 (10.3)	28 (96.6)	
Total, N (%)	25 (86.2)	4 (13.8)	29 (100.0)	

Table 2. Cross-tabulation between results of denture type and denture PCR test

	Denture Type			
Denture PCR	**Partial, N (%)**	**Complete, N (%)**	**Total, N (%)**	***P***
Negative, N (%)	3 (100.0)	22 (84.6)	25 (86.2)	1.000
Positive, N (%)	0 (0.0)	4 (15.4)	4 (13.8)	
Total, N (%)	3 (100.0)	26 (100.0)	29 (100.0)	

significant relationship between the type of denture and the result of the denture PCR test (P=1.000). Two of the 4 positive denture PCR findings were weak (both Ct=34), while the other 2 were stronger (Ct=30 and Ct=32).

DISCUSSION

Bacterial and fungal removable denture plaque has been reported to accumulate because of acrylic resin porosity and the structural nature of the denture base.[10] However, the authors are unaware of studies on viral contamination of acrylic resin dentures. Initially, it was hypothesized that the accumulation and proliferation of pathogenic pathogens on denture surfaces could be a source of infection for patients, dental and medical staff, and dental laboratory technicians, increasing the risk of transmission of viral infection. The present study aimed to investigate the presence of viral contamination on the acrylic resin base of removable prostheses in patients diagnosed with COVID-19. Despite the microporosity of the acrylic resin base, no significant viral contamination was identified. Therefore, the research hypothesis that COVID-19 virus would be detected on the intaglio surface of dentures in patients diagnosed with COVID-19 was rejected.

Mechanical methods, such as brushing, have been used to remove microbial plaque, although most patients are unable to completely remove this plaque because of anatomic and technical reasons. Acrylic resin prostheses promote plaque formation and infection, and denture hygiene is challenging, especially for the elderly and disabled.[14]

Coronavirus substrate analysis showed that the diameter of the COVID-19 virus and the length of its crown-like spikes were 60 to 140 nm and 9 to 12 nm, respectively. If the porosity of the acrylic resin prosthesis is less than 60 nm, the contact between the virus and the surface is likely to be effectively reduced; as a result, the virus attachment to the surface is minimized.[15] Moreover, the microporosity in the acrylic resin is affected by the polymerization method. Accordingly, during polymerization in a water bath, minimum porosity is created inside the acrylic resin denture base, but the porosity of acrylic resins polymerized by microwave energy is slightly increased.[16]

The SARS-CoV-2 virus has been reported to be composed of pleomorphic particles that are not entirely spherical and vary in size and shape. Furthermore, its outer layer consists of a lipid hydrophobic coating,[17] which may lower adhesion to other microorganisms. The microporous acrylic resin surface also has antibiofouling properties, which reduces the surface of the virus in contact with the acrylic resin denture area by trapping air between these pores.[15]

According to the sampling in the present study, 1 of the 4 patients with a positive PCR result from the denture had a negative PCR result in the medical record, probably because of the variable clock rate of the virus. A study conducted in the United States in 2020 reported that positive tests showed a sinusoidal pattern with a peak point of 1:49 PM, 24 hours a day.[18] They also reported that the rate of positive tests at the peak point was 2.2 times higher than that at the lowest point of the curve. Therefore, the sinusoidal pattern in this study shows that the amount of virus in the mucosa varies with the cyclic pattern and the maximum amount at the beginning of each day. This pattern has also been observed in other viruses such as influenza and herpes.[18] The positive PCR of dentures with the negative result of the hospital PCR test can be explained by the low rate of the virus at the time of sampling.

Limitations of the present study included the prohibition on culturing the coronavirus and the in vitro design. Confounding factors included that the acrylic resin removable denture bases had not been polymerized consistently in all patients and that some had been repaired with autopolymerizing acrylic resin. Other limitations included the lack of previous similar studies, so the sample size was calculated from a study that is not related to COVID-19. Therefore, the calculated sample size may be less than that actually required. In addition, it was not possible to sample in the same stages of the disease, which could affect the viral load. Patients in the first days of the disease have a higher viral load than those who have passed the peak of the disease. This limitation could affect the sampling results of the present study.

Investigating the depth of the contamination of the acrylic resin prosthetic bases was not possible without the denture bases being altered because of the risk of reducing denture performance. Making a new denture for patients with severe disease may be associated with complications.

Future studies should be performed under more controlled conditions. Different hypotheses that should

be tested include that the atrophy of the salivary glands caused by prolonged denture pressure may also reduce viral load after salivation; that reducing the amount of saliva flow caused by anticorona drugs may reduce the viral load of saliva; that the components of acrylic resin and monomer chemical compounds may have possible antiviral properties; and that bacterial and fungal plaques, as well as the patient's oral health, may play a role in the adhesion of coronavirus to the acrylic resin base.

CONCLUSIONS

Based on the findings of this in vitro study, the following conclusions were drawn:

1. Despite the microporous structure of the acrylic resin base, no significant viral contamination was observed, and this relationship was not statistically significant.
2. Because of the novelty of the study and the lack of similar previous studies, further controlled research in this domain is required.

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Corresponding author:
Dr Mohammad Ebrahimi Saravi
Department of Prosthodontics, Faculty of Dentistry
Mazandaran University of Medical Sciences
Khazar St, Sari
IRAN
Email: mohammadebrahimisaravi@gmail.com

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CRediT authorship contribution statement
Nadia Elyassi Gorji: Investigation, Writing – original draft, Writing – review & editing, Conceptualization. **Negareh Salehabadi:** Writing – original draft, Writing – review & editing, Data curation, Conceptualization. **Zakaria Zakariaei:** Methodology, Resources, Supervision. **Jamshid Yazdani Cherati:** Formal analysis, Data curation. **Leila Delavaryan:** Methodology, Resources. **Mohammad Ebrahimi Saravi:** Conceptualization, Project administration, Supervision, Writing – review & editing, Validation.

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