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The coronavirus of the Coronaviridae family has a long, single, plus-stranded ribonucleic acid (RNA) 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, which, after spreading to other countries, was designated a pandemic by the World Health Organization.

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

Removable dentures made with porous materials provide a favorable environment for the growth of microorganisms. 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 ZUMS. 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. 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 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...
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. 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.

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. 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.

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, which may lower adhesion to other microorganisms. The microporous acrylic resin surface also has antifouling properties, which reduces the surface of the virus in contact with the acrylic resin denture area by trapping air between these pores.

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. 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. 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 anticoona 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.

REFERENCES

1. Peng X, Xu X, Li Y, Cheng L, Zhou X, Ren B. Transmission routes of 2019-nCoV and controls in dental practice. Int J Oral Sci 2020;12:1-6.
2. Al-Tawfiq JA, Zumla A, Memish ZA. Travel implications of emerging coronaviruses: SARS and MERS-CoV. Travel Med Infect Dis 2014;12:422-8.
3. Rothan HA, Byrareddy SN. The epidemiology and pathogenesis of coronavirus disease (COVID-19) outbreak. J Autoimmun 2020;109:102433.
4. Sarma P, Shekhar N, Prajapati M, Avri P, Kaur H, Kumar S, et al. In-silico homology assisted identification of inhibitor of RNA binding against 2019-nCoV N-protein (N terminal domain). J Biomol Struct Dyn 2020;39:2724-32.
5. Liu L, Wei Q, Alvarez X, Wang H, Du Y, Zhu H, et al. Epithelial cells lining salivary gland ducts are early target cells of severe acute respiratory syndrome coronavirus infection in the upper respiratory tracts of rhesus macaques. J Virol 2011;85:4025-30.
6. To KK-W, Tsang OT-Y, Yip CC-Y, Chan K-H, Wu T-C, Chan JM-C, et al. Consistent detection of 2019 novel coronavirus in saliva. Clin Infect Dis 2020;71:841-3.
7. To KK-W, Tsang OT-Y, Leung W-S, Tam AR, Wu T-C, Lung DC, et al. Temporal profiles of viral load in posterior oropharyngeal saliva samples and serum antibody responses during infection by SARS-CoV-2: an observational cohort study. Lancet Infect Dis 2020;20:565-74.
8. Tian H. 2019-nCoV: new challenges from coronavirus. Zhonghua Yu Fa Chong Bing Za Zhi 2020;54:E001.
9. Jafari A, Lotfi-Kamran MH, Hoseinzadeh A, Ashoori H. Comparison of Candida colonization in smoker and non-smokers’ saliva of compete denture users. J Mashhad Dent Sch 2013;37:281-90.
10. Przybyłowiska D, Mierzwińska-Nastalska E, Swoboda-Kopeć E, Ruhinsztajn R, Chazan R. Potential respiratory pathogens colonisation of the denture plaque of patients with chronic obstructive pulmonary disease. Gerodontology 2016;33:3-7.
11. Mancini F, Barbanti F, Scaturo M, Fontana S, Di Martino A, Mamili G, et al. Multiplex real-time reverse-transcription polymerase chain reaction assays for diagnostic testing of severe acute respiratory syndrome coronavirus 2 and seasonal influenza viruses: a challenge of the phase 3 pandemic setting. J Infect Dis 2021;223:765-74.
12. Rao SN, Manissero D, Steele VR, Pareja J. A narrative systematic review of the clinical utility of cycle threshold values in the context of COVID-19. Infect Dis Ther 2020;9:573-86.
13. Trunfio M, Venuti F, Alladio F, Longo BM, Burdino E, Cerutti F, et al. Diagnostic SARS-CoV-2 cycle threshold value predicts disease severity, survival, and six-month sequelae in COVID-19 symptomatic patients. Viruses 2021;13:281.
14. Philip JM, Rebecca L, Abraham HM, Venkatakrishnan C, Chandran CR, Anbuselvi S. Current trends in reducing microbial adhesion to acrylic denture base resins. Drug Invent Today 2018;10:946-9.
15. Sudique AY, Agrawal A, Joshi SS. Surface alterations to impart antiviral properties to combat COVID-19 transmission. Trans Indian Natl Acad Eng 2020;5:343-7.
16. Singh S, Palaskar JN, Mittal S. Comparative evaluation of surface porosities in conventional heat polymerized acrylic resin cured by water bath and microwave energy with microwave cured acrylic resin cured by microwave energy. Contemp Clin Dent 2013;4:147-51.
17. Baglivo M, Baronio M, Natalini G, Beccari T, Chiurazzi P, Fulcheri E, et al. Natural small molecules as inhibitors of coronavirus lipid-dependent attachment to host cells: a possible strategy for reducing SARS-CoV-2 infectivity? Acta Biomed 2020;91:161-4.
18. McNaughton CD, Adams NM, Johnson CH, Ward MJ, Lasko TA. Diurnal variation in SARS-CoV-2 PCR test results: test accuracy may vary by time of day. medRxiv 2021;3:21253015.

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