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Original Article

Correlation Between Periodontitis and COVID-19 Severity Assessed by HRCT Chest Scan Scores

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ABSTRACT

Emerging hypotheses suggest a potential connection between periodontitis and COVID-19, yet concrete evidence is scarce. This study aimed to explore whether periodontitis is linked to the severity of COVID-19. In this cross-sectional study, COVID-19 patients were classified into mild, moderate, and severe groups based on high-resolution chest CT (HRCT) severity scores. Comprehensive periodontal assessments—including plaque index (PI), bleeding on probing (BOP), probing depth (PD), gingival recession (REC), clinical attachment loss (CAL), and counts of mobile and teeth lost due to periodontitis—were recorded for each patient. Data were analyzed using appropriate statistical methods. Among the 294 participants, 149 (50.7%) presented with periodontitis, with the highest occurrence (87.5%) in the severe COVID-19 group. Advanced stages of periodontitis (stage III–IV) were significantly more prevalent among patients with severe COVID-19 than in those with milder forms. HRCT severity scores demonstrated a moderate positive association with worsened periodontal measures. Patients with periodontitis had a 2.81 times greater likelihood of developing severe COVID-19, indicating a significant association between periodontal disease and increased COVID-19 severity.

Keywords: Risk predictor, COVID-19, Cytokine storm, Periodontitis, High-resolution computed tomography

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Introduction

Coronavirus disease 2019 (COVID-19), caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), emerged as a major global health challenge and was first reported in Wuhan, China, in December 2019 [1]. While SARS-CoV-2 infection can impact multiple organ systems, the lungs are most frequently affected [2]. Although many patients experience mild, influenza-like symptoms, some develop severe pneumonia and acute respiratory distress syndrome (ARDS), which can result in death [3].

The standard method for confirming COVID-19 infection is the real-time reverse-transcriptase polymerase chain reaction (rRT-PCR) test [4]. In addition, non-contrast high-resolution computed tomography (HRCT) of the chest has been shown to be valuable for early disease detection and patient management [1]. Typical CT features in COVID-19 include bilateral, peripheral, and basal ground-glass opacities, sometimes accompanied by consolidation and bronchovascular thickening [5]. HRCT is highly sensitive and useful not only for evaluating pneumonia severity in confirmed cases but also for tracking disease progression [1]. Quantification of disease burden can be performed by assessing the percentage of lung involvement, often assisted by deep learning algorithms [6, 7]. The HRCT severity score (CT-SS) has also been positively associated with clinical and laboratory markers—including C-reactive protein, serum ferritin, lymphopenia, D-dimer levels, length of hospital stay, and oxygen requirements [8-11].

The COVID-19 pandemic has posed unprecedented challenges to understanding disease pathophysiology [12]. Identifying factors that may influence disease progression remains critical for optimizing patient care [13]. Even with widespread vaccination, this remains a priority [13]. Recent studies have highlighted that chronic conditions such as cardiovascular disease, hypertension, diabetes, obesity, and chronic kidney disease are associated with more severe COVID-19 [14]. Periodontitis—a common chronic oral disease—may also be linked to COVID-19 outcomes.

According to the 2016 Global Burden of Disease Study, severe periodontal disease ranks as the 11th most prevalent condition worldwide [15]. Although periodontitis is nonfatal, it affects not only oral health but also contributes to systemic pathologies. Substantial evidence links periodontal disease with respiratory illnesses such as pneumonia and chronic obstructive pulmonary disease (COPD) [16]. Proposed mechanisms include direct aspiration of pathogens into the lungs, alterations of mucosal surfaces facilitating colonization, disruption of salivary bacterial pellicles, and cytokine-mediated modification of respiratory epithelium [17].

Several studies, ranging from theoretical models to clinical observations and reviews, have suggested a relationship between periodontitis and COVID-19 [18-22]. Periodontitis is characterized by a dysregulated cytokine response [23], which may overlap with the cytokine storm observed in severe COVID-19, potentially worsening outcomes [23]. Hypothetical models propose that periodontal disease could predict adverse COVID-19 outcomes [24, 25]. Effective management of severe COVID-19 is essential to minimize complications and mortality, making it important to explore whether periodontitis may contribute to disease severity alongside known risk factors. Therefore, this study aimed to evaluate the periodontal condition of patients with varying COVID-19 severity and to investigate a potential association between periodontitis and COVID-19. The null hypothesis proposed is that periodontal disease does not influence the risk or severity of SARS-CoV-2 infection.

Materials and Methods

Study design

This cross-sectional study was carried out over a period of five months, from April 2021 to August 2021, at the Outpatient Department of Periodontics, Government Dental College and Hospital, Raipur, Chhattisgarh, India. Ethical clearance was obtained from the institution's review board prior to initiating the study, following the revised 2013 Helsinki Declaration (ECB/2334/GDC/CG/12.04.2021).

Participants included COVID-19-positive patients registered in the state's COVID-19 monitoring system maintained by the Department of Health and Family Welfare. The study authors, S.M. and V.G., who are licensed physicians registered with the monitoring system and actively provide care to COVID-19 patients, obtained patient contact information. Patients were approached via telephone, where the study's purpose and objectives were explained, and informed consent was obtained prior to data collection. Demographic information (age and sex) and records of rRT-PCR testing and HRCT chest scans were collected. Only patients aged 18 years or older, confirmed positive for COVID-19 via rRT-PCR, and who had undergone HRCT chest imaging 9–13 days after symptom onset (corresponding to the peak period of lung involvement in COVID-19) were included. Pregnant women were excluded from the study.

The HRCT severity score (CT-SS) employed a semiquantitative system to evaluate involvement in each of the five lung lobes [2, 26]. Each lobe was scored from 0 to 5: 0 for no involvement, 1 for <5% involvement, 2 for 5–25%, 3 for 26–49%, 4 for 50–75%, and 5 for >75% involvement. The total CT-SS, calculated by summing the scores of all lobes, ranged from 0 (no involvement) to 25 (maximum involvement). Based on the CT-SS, patients were categorized into three groups: mild (score 1–8, group I), moderate (score 9–15, group II), and severe (score ≥15, group III) COVID-19.

Assessment of covariates

Several factors have been linked to COVID-19 severity in previous studies, including demographics (age, sex), body mass index (BMI), smoking habits, and the presence of comorbid conditions such as diabetes mellitus (DM), hypertension (HT), cardiovascular or cerebrovascular diseases, asthma or chronic lung disorders, neurological conditions, cancers, gastrointestinal illnesses, and pregnancy. Therefore, these variables were recorded prior to the clinical examination. BMI was calculated as weight in kilograms divided by height in meters squared and categorized according to revised Indian guidelines: underweight/normal (BMI <18.5–22.9 kg/m²) and overweight/obese (BMI 23–24.9 kg/m² / ≥25 kg/m²). Smoking status was documented as current smoker or former/never smoker. A comprehensive medical history was obtained for each participant, with systemic conditions other than DM and HT grouped under "other comorbidities."

Clinical examination

Periodontal assessments were performed only after participants tested negative for COVID-19 using rRT-PCR. A single examiner (W.R.), blinded to the study protocol, conducted all evaluations. Calibration was completed prior to the study on six randomly selected periodontitis patients who were not included in the main sample; two measurements of probing depth (PD) and clinical attachment level (CAL) were recorded 24 hours apart, showing high reproducibility with 93 percent of PD and 91 percent of CAL readings differing by ≤1 mm.

All permanent teeth, excluding third molars, were examined for plaque index (PI), bleeding on probing (BOP), probing pocket depth (PD), gingival recession (REC), clinical attachment level (CAL), number of mobile teeth, and teeth lost due to periodontitis. Measurements were taken using a mouth mirror and UNC-15 periodontal probe (Hu-Friedy, Chicago, IL, USA) and rounded to the nearest millimeter. PI was scored on labial, lingual, and interproximal surfaces according to Silness and Loe [27]. BOP was evaluated by probing each site for 30 seconds and calculating the ratio of bleeding sites to total sites examined [19]. PD, REC, and CAL were recorded at six sites per tooth. Teeth were considered missing due to periodontitis if the patient reported prior mobility or extraction resulting from periodontal disease, excluding trauma-related loss. Full-mouth intraoral periapical radiographs using the long-cone technique were obtained to assess alveolar bone loss. Oral hygiene behavior, particularly frequency of daily tooth brushing, was documented. Periodontal status was classified following the 2017 World Workshop guidelines [28], and periodontitis cases were staged I–IV based on criteria by Tonetti *et al*. [29].

Sample size and statistical methods

The required sample size was calculated using MedCalc version 20.011, referencing Marouf *et al*. [18], which reported a 13% prevalence of periodontitis among COVID-19 patients with complications. At a 95% confidence level ($\alpha = 0.05$), a minimum of 174 participants was needed. Statistical analyses were performed with SPSS 22.0 (IBM Corp., Armonk, NY, USA). Categorical variables were summarized as counts and percentages, while continuous data were presented as mean ± SD. Normality was checked using the Shapiro–Wilk test. The chi-square test compared categorical variables between groups, and one-way ANOVA assessed differences in normally distributed continuous variables across the three COVID-19 severity groups. Pearson correlation coefficients were used to examine relationships between CT-SS and periodontal parameters. Multinomial logistic regression was conducted to quantify the association between periodontitis and COVID-19 severity, including known risk factors regardless of univariate significance. Crude and adjusted odds ratios (ORs) with 95% confidence intervals (CIs) were reported, with $p < 0.05$ considered statistically significant.

Results and Discussion

From 1,088 COVID-19-positive patients screened, 121 were under 18 years of age, 197 tested negative via alternative methods, and 254 lacked HRCT chest scans; these patients were excluded, leaving 516 eligible participants. Among them, 312 consented, but 18 patients died from COVID-19, resulting in a final sample of 294 patients. This cohort included 163 patients with mild, 83 with moderate, and 48 with severe COVID-19. **Table 1** summarizes the demographic and clinical data. Patients with severe COVID-19 were older (mean 51.87 ± 7.08 years, $p < 0.0001$) and had higher BMI (22.57 ± 1.23, $p = 0.001$) compared with the other groups. Diabetes (56.25 percent, $p = 0.002$) and hypertension (56.25 percent, $p = 0.0003$) were also more common in the severe group. Oral hygiene habits differed, with 41.10% of mild COVID-19 patients brushing twice daily ($p = 0.04$). Other variables did not differ significantly among the groups.

Table 1. Participant details among the three COVID-19 pneumonia groups.

	COVID-19 Pneumonia			
Variable	**Mild**	**Moderate**	**Severe**	**p-Value**
	(n = 163)	(n = 83)	(n = 48)	
Age (in years)	38.41 ± 7.31	41.42 ± 7.72	51.87 ± 7.08	<0.0001 **
Gender (n/%)				
Male	84 (51.53%)	43 (51.8%)	27 (56.25%)	
Female	79 (48.47%)	40 (48.19%)	21 (43.75%)	0.84
BMI (Kg/m^2)	21.86 ± 1.09	22.18 ± 1.33	22.57 ± 1.23	0.001 *

Smoking status (n/%)				
Yes	39 (23.93%)	20(25.10%)	15 (31.25%)	
No	124 (76.07%)	63 (75.90%)	33 (68.75%)	0.57
Diabetes status (n/%)				
Yes	47 (28.83%)	32 (38.55%)	27 (56.25%)	
No	116 (71.17%)	51 (61.45%)	21 (43.75%)	0.002 *
Hypertension (n/%)				
Yes	44 (27%)	22 (26.50%)	27 (56.25%)	
No	119 (73%)	61(73.50%)	21 (43.75%)	0.0003 *
Other co-morbidities				
Yes	14 (8.58%)	10 (12.05%)	6 (12.5%)	0.59
No	149 (91.41%)	73 (87.95%)	42 (87.5%)	
Oral hygiene practice				
Once daily	96(58.89%)	62 (74.69%)	33 (68.75%)	
Twice daily	67(41.10%)	21 (25.31%)	15 (31.25%)	0.04 *

n = number of participants, % = percentage, mod. = moderate, SD = standard deviation, kg = kilogram, m = meter. * indicates Fisher's exact test was applied, with $p < 0.05$ considered statistically significant; ** indicates one-way ANOVA was used, with $p < 0.05$ considered statistically significant.

Table 2 summarizes the comparison of periodontal parameters across the three COVID-19 severity groups. Among the 294 participants, 149 (50.68%) were diagnosed with periodontitis, 79 (26.87 percent) had gingivitis, and 66 (22.45%) showed healthy periodontal status. Within the periodontitis subgroup, the severe COVID-19 group had a markedly higher proportion of affected individuals (87.5%) compared with the mild and moderate groups ($p < 0.0001$). For gingivitis, 79 participants were affected, with a slightly higher prevalence in the moderate COVID-19 group (30%), showing a weakly significant association ($p = 0.048$). Regarding periodontitis severity, generalized stage I–II disease was more common in patients with mild COVID-19 (84.44 percent, $p < 0.0001$), whereas generalized stage III–IV periodontitis was significantly more frequent in the severe COVID-19 group (81.82 percent, $p < 0.0001$).

Table 2. Comparison of periodontal parameters between the three COVID-19 pneumonia groups.

Variable	COVID-19 Pneumonia			p-Value
	Mild	Moderate	Severe	
	(n = 163)	(n = 83)	(n = 48)	
Periodontitis (149)	70 (42.94%)	37 (44.58%)	42 (87.5%)	<0.0001 *
Gingivitis (79)	48 (29.44%)	25 (30.12%)	06 (12.5%)	0.048 *
Healthy (66)	45 (27.60%)	21 (25.30%)	0 (00.00%)	0.598
Frequency				
Stage I–II (n/%)	45 (64.28%)	15 (40.54%)	09 (21.43%)	<0.0001 *
Stage III–IV (n/%)	25 (35.72%)	22 (59.46%)	33 (78.57%)	
Frequency				
Stage I–II (n/%)				
Localized	07 (15.56%)	04 (26.67%)	03 (33.33%)	0.37
Generalized	38 (84.44%)	11 (73.33%)	06 (66.67%)	
Stage III–IV (n/%)				
Localized	06 (24%)	05 (22.72%)	06 (18.18%)	0.84
Generalized	19 (76%)	17 (77.28%)	27 (81.82%)	
Mean PI				
Healthy	0.25 ± 0.20	0.37 ± 0.33	X	0.18
Gingivitis	1.44 ± 0.64	1.85 ± 0.35	1.92 ± 0.40	<0.0001 *
Periodontitis	1.90 ± 0.35	2.02 ± 0.43	2.11 ± 0.45	0.002 *

Mean BOP				
Healthy	0.03 ± 0.06	0.10 ± 0.12	X	0.055
Gingivitis	0.60 ± 0.30	0.78 ± 0.18	0.90 ± 0.13	<0.0001 *
Periodontitis	0.80 ± 0.25	0.86 ± 0.26	0.90 ± 0.16	0.02 *
Mean PD				
Healthy	1.91 ± 0.36	2.12 ± 0.45	X	0.42
Gingivitis	2.40 ± 0.24	2.5 ± 0.16	3.0 ± 0.29	<0.0001 *
Periodontitis	3.59 ± 0.89	4.48 ± 0.80	4.9 ± 0.75	<0.0001 *
Mean REC				
Healthy	0.03 ± 0.07	0.11 ± 0.25	X	0.27
Gingivitis	0.01 ± 0.03	0.04 ± 0.11	0	0.18
Periodontitis	0.73 ± 0.71	0.87 ± 0.69	1.11 ± 0.78	0.00 *
Mean CAL				
Healthy	0.02 ± 0.05	0.05 ± 0.10	X	0.87
Gingivitis	0.01 ± 0.03	0.05 ± 0.14	0	0.14
Periodontitis	3.75 ± 1.19	4.73 ± 1.07	5.31 ± 0.93	<0.0001 *

n = number of participants, % = percentage, PI = plaque index, BOP = proportion of sites with bleeding on probing, PD = pocket depth, REC = gingival recession, CAL = clinical attachment loss, X = none, * indicates p-values < 0.05 considered statistically significant. The mean values for all periodontal measures—PI, BOP ratio, PD, REC, and CAL—were significantly elevated in the severe COVID-19 group (PI: 2.11 ± 0.45, p = 0.002; BOP: 0.90 ± 0.16, p = 0.02; PD: 4.9 ± 0.75, p < 0.0001; REC: 1.11 ± 0.78, p = 0.005; CAL: 5.31 ± 0.93, p < 0.0001). Among participants with gingivitis, those in the severe COVID-19 group also exhibited significantly higher mean PI, BOP ratio, and PD compared to the mild and moderate groups (PI: 1.92 ± 0.40, p < 0.0001; BOP: 0.90 ± 0.13, p < 0.0001; PD: 3.0 ± 0.29, p < 0.0001).

When examining patients with stage I–II periodontitis, those who developed severe COVID-19 pneumonia had notably higher mean probing depth and clinical attachment loss than patients in the mild and moderate groups (PD: 3.74 ± 0.12, p < 0.0001; CAL: 3.84 ± 0.31, p = 0.003). In the subgroup with stage III–IV periodontitis, individuals with severe COVID-19 also displayed significantly elevated periodontal damage, with higher mean PD, CAL, and number of mobile teeth compared to the less severe groups (PD: 5.22 ± 0.47, p = 0.001; CAL: 5.71 ± 0.53, p = 0.01; mobile teeth: 4.63 ± 1.20, p = 0.006). Comprehensive data for these comparisons are shown in **Table 3**.

Table 3. Comparison of periodontal parameters of periodontitis patients between the three COVID-19 groups.

Variable	COVID-19 Pneumonia			p-Value
	Mild	Moderate	Severe	
Stage I–II Periodontitis				
Mean PI	1.82 ± 0.33	1.83 ± 0.47	1.92 ± 0.22	0.74
Mean BOP	0.72 ± 0.15	0.73 ± 0.18	0.74 ± 0.22	0.94
Mean PD	3.08 ± 0.53	3.61 ± 0.29	3.74 ± 0.12	<0.0001 *
Mean REC	0.27 ± 0.34	0.27 ± 0.35	0.40 ± 0.35	0.81
Mean CAL	3.03 ± 0.75	3.69 ± 0.49	3.84 ± 0.31	0.003 *
Mobile teeth	0.68 ± 0.87	1.20 ± 0.97	1.0 ± 1.00	0.15
Missing teeth	0.44 ± 0.69	0.53 ± 0.91	0.33 ± 0.57	0.88
Stage III–IV Periodontitis				
Mean PI	2.05 ± 0.35	2.15 ± 0.36	2.16 ± 0.49	0.59
Mean BOP	0.79 ± 0.16	0.83 ± 0.16	0.86 ± 0.14	0.43
Mean PD	4.55 ± 0.66	5.07 ± 0.37	5.22 ± 0.47	0.001 *
Mean REC	1.11 ± 0.82	1.27 ± 0.76	1.30 ± 0.76	0.71
Mean CAL	5.04 ± 0.57	5.44 ± 0.72	5.71 ± 0.53	0.01 *
Mobile teeth	2.76 ± 1.66	4.04 ± 1.96	4.63 ± 1.20	0.006 *
Missing teeth	1.20 ± 1.35	1.63 ± 1.78	2.27 ± 2.05	0.21

PI = plaque index, BOP = proportion of sites showing bleeding on probing, PD = probing pocket depth, REC = gingival recession, CAL = clinical attachment level; * indicates p-values < 0.05 are considered statistically significant.

Irrespective of periodontitis stage, the analysis revealed a significant moderate positive correlation between CT-SS and periodontal parameters. Specifically, each one-unit increase in CT-SS was associated with an increase of 0.57 in PI ($p < 0.0001$), 0.53 in the proportion of sites with BOP ($p < 0.0001$), 0.63 mm in PD ($p < 0.0001$), 0.54 mm in REC ($p < 0.0001$), and 0.64 mm in CAL ($p < 0.0001$) **(Table 4)**.

Table 4. Correlation of HRCT scores with periodontal parameters.

Variable	PI	BOP	PD	REC	CAL
	r (p-value)	r (p-value)	r (p-value)	r (p-value)	r (p-value)
CT-SS *	0.57	0.53	0.63	0.54	0.64
	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)

PI = plaque index, BOP = proportion of sites with bleeding on probing, PD = probing pocket depth, REC = gingival recession, CAL = clinical attachment level, HRCT-SS = high-resolution computed tomography severity score; * indicates p-values < 0.05 are considered statistically significant.

The crude odds ratio (OR) for developing severe COVID-19 among patients with periodontitis was 9.09 (95% CI: 3.73–22.18, $p < 0.0001$). After adjusting for all covariates in a multinomial logistic regression model, the adjusted OR for severe COVID-19 in periodontitis patients was 2.81 (95% CI: 0.41–19.75, $p = 0.004$), with age being the only significant predictor of severe disease **(Table 5)**. The model demonstrated a satisfactory fit, with a Nagelkerke R^2 of 0.4604 ($p < 0.0001$). No significant associations were observed between periodontitis and either moderate or mild COVID-19 ($p > 0.05$).

Table 5. Multinomial logistic regression analysis.

Variable	Odds Ratio	95% CI	p-Value
Periodontitis	2.81	0.40 to 19.75	0.004 *
Age	1.38	1.20 to 1.58	<0.0001 *
Female gender	1.02	0.21 to 5.10	0.9773
BMI	1.00	0.51 to 1.95	0.9968
Smoking status	5.21	0.87 to 31.32	0.0714
DM status	0.24	0.06 to 1.04	0.0559
HT status	0.46	0.11 to 1.95	0.2955
OHP	1.49	0.37 to 5.9428	0.5702

BMI = body mass index, DM = diabetes mellitus, HT = hypertension, OHP = oral hygiene practices; * indicates p-values < 0.05 are considered statistically significant.

Discussion

Evidence continues to emerge showing that certain individuals are more susceptible to experiencing severe complications from COVID-19. Factors such as advanced age, male sex, obesity, abnormal vital signs, and the presence of chronic medical conditions—including diabetes mellitus, hypertension, and chronic lung diseases—have all been linked to an elevated risk of severe COVID-19 and poor outcomes [24, 30]. Consequently, numerous predictive models have been developed to identify and stratify high-risk patients. The current study contributes to this body of research by suggesting that periodontitis may also serve as a risk factor for severe COVID-19.

Our findings demonstrate a significant association between periodontitis and severe COVID-19, with the prevalence and severity of periodontitis being higher among patients with severe disease. This suggests that periodontal health may influence the progression and outcomes of COVID-19. Notably, after controlling for established risk factors, periodontitis remained significantly correlated with severe COVID-19, whereas no significant associations were observed with moderate or mild COVID-19.

Few studies have investigated the link between periodontitis and COVID-19 severity, and the present study adds to this limited evidence. Our results align with previous reports [13, 18, 19]. Unlike Marouf *et al.* [18], who relied solely on interdental bone loss measured from archived orthopantomographs—potentially limiting diagnostic accuracy—our study performed a comprehensive periodontal assessment, including clinical parameters and alveolar bone evaluation for disease staging. Similarly, Anand *et al.* [19] classified patients only by COVID-19 status without considering disease severity; in contrast, our

study stratified patients based on HRCT chest imaging and severity scores, offering a more detailed evaluation of the relationship between periodontitis and COVID-19. To minimize the risk of viral transmission, clinical examinations were conducted only after patients tested negative for COVID-19.

The severity of COVID-19 in this study was assessed using HRCT chest scans. Pulmonary changes resembling pneumonia are commonly observed in COVID-19 patients [5, 31], whereas the absence of lung abnormalities generally indicates a lower risk of progression to severe disease. Ground-glass opacities, along with line-like and patchy consolidations, are the most frequently reported CT findings [7, 31]. Bilateral lung involvement, multiple lobe engagement, and rapid lesion progression are important markers for severe disease development. While routine CT screening for COVID-19 is not recommended by the WHO, CT imaging can be valuable in certain situations, such as when rRT-PCR testing is unavailable or when highly suspected cases yield negative PCR results. In this study, rRT-PCR testing was used to confirm COVID-19 diagnosis, and HRCT imaging was employed to evaluate disease severity, reflecting its recognized utility in detecting pulmonary abnormalities [31]. Prior studies have also shown strong correlations between CT-SS and clinical/laboratory parameters, oxygen requirements, and hospital stay duration, supporting its prognostic value [8-11].

Among systemic risk factors, diabetes mellitus, hypertension, and obesity have consistently been associated with the most adverse COVID-19 outcomes, including increased hospitalization rates [3, 31, 32]. Advanced age is also a well-established risk factor for severe manifestations of SARS-CoV-2 infection [31, 33].

The findings of this study align with previous reports, showing that older and obese individuals with diabetes and hypertension are more likely to experience severe COVID-19. However, multinomial logistic regression identified age as the sole significant predictor of severe illness, with periodontitis exhibiting an age-dependent influence. Given that untreated periodontitis represents a chronic low-grade systemic inflammatory condition and is closely linked with other chronic diseases, it is plausible that its presence may indirectly amplify the impact of these comorbidities on COVID-19 outcomes. Previous research has demonstrated the presence of periodontopathic bacteria in the bronchoalveolar fluid of patients with hospital-acquired pneumonia and highlighted the increased risk of respiratory conditions such as aspiration pneumonia and COPD in individuals with advanced periodontitis [34-36]. Consequently, several theoretical models propose a potential direct role of periodontitis in exacerbating COVID-19, given that SARS-CoV-2 primarily targets the respiratory system [13, 21, 37].

Viral infection requires binding to host cellular receptors, and for SARS-CoV-2, the receptor is angiotensin-converting enzyme 2 (ACE2), which is abundantly expressed in the oral cavity, particularly on the tongue and gingiva, suggesting that the oral cavity may serve as a site for viral entry and transmission [21, 38, 39]. Moreover, inadequate plaque control leading to excessive accumulation of periodontopathic bacteria may increase the risk of severe outcomes in COVID-19, emphasizing the importance of assessing oral health in affected patients [38]. In the present study, individuals with severe COVID-19 exhibited poorer oral hygiene, evidenced by higher plaque indices and more sites with gingival bleeding. Aspiration of periodontal pathogens could further worsen SARS-CoV-2 infection by increasing ACE2 expression [18, 19, 21].

Some studies suggest that while periodontal pathogens may not directly infect the lungs, their continuous aspiration could trigger excessive production of inflammatory cytokines such as IL-6 and IL-8 by respiratory cells [40]. This cytokine overproduction, commonly referred to as a cytokine storm, is thought to contribute significantly to COVID-19 progression, including ARDS and elevated mortality rates [13, 40]. Additionally, proteases from aspirated periodontal bacteria may enhance SARS-CoV-2 infectivity by promoting degradation of the viral S protein [21]. Therefore, maintaining rigorous oral hygiene could be a valuable adjunct to mitigate severe COVID-19 outcomes, as supported by our observation that patients practicing oral hygiene twice daily tended to have milder disease.

A key limitation of this study was the lack of periodontal assessment during the acute phase of COVID-19. Nevertheless, because periodontitis is a chronic inflammatory disease, it is likely that affected individuals already had the condition prior to SARS-CoV-2 infection. Other limitations include the omission of alveolar bone loss evaluation, inability to track periodontitis development during illness, a relatively small sample of severe COVID-19 patients, and the observational nature of the study, which precludes establishing causality. Nonetheless, these findings underscore the need for further research to elucidate the role of periodontitis in COVID-19, which could inform early detection, management, and clinical decision-making.

Conclusion

This study suggests an association between periodontitis and severe COVID-19, although whether this link is direct or indirect remains unclear and warrants further investigation. Regardless, assessment and management of periodontal health should be integrated into COVID-19 care protocols, as maintaining oral health and addressing periodontitis may reduce the risk of severe disease.

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