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Oral Hygiene Status and Renal Function in Pre-Dialysis Chronic Kidney Disease Patients in a Nigerian Tertiary Hospital: A Cross-Sectional Study

Onabanjo OA[1], Ogunwemimo MT[2], Ogundiran T[1], Adewole OM[1], Ogunleye BA[1], Nwhator SO[2], Arogundade FA[3]
[1]Department of Preventive & Community Dentistry, Obafemi Awolowo University Teaching Hospitals Complex, Nigeria
[2]Department of Preventive & Community Dentistry, Obafemi Awolowo University, Ile-Ife, NIgeria
[3] Department of Medicine, Obafemi Awolowo University, Ile-Ife, Nigeria

Correspondence: Onabanjo OA
Email: unshakabledestiny@gmail.com

ABSTRACT

Background: Poor oral health and chronic kidney disease have been linked in several studies. Also, there are many reports on the oral hygiene status of hemodialysis and peritoneal dialysis patients. However, very few have been reported in pre-dialysis patients, especially in developing countries. Therefore, this study investigated oral hygiene status and its implication on renal function of pre-dialysis chronic kidney disease patients attending a tertiary health care facility in Nigeria.

Methods: This was a cross-sectional study conducted between June 2019 and December 2020 at the nephrology unit, Department of Medicine, Obafemi Awolowo University Teaching Hospitals Complex (OAUTHC), Ile-Ife, Osun State, Nigeria among pre-dialysis chronic kidney disease (CKD) Stages 1–5 patients who were 18 years and above. The study involved two groups: those with periodontitis and those without periodontitis (control). Self-administered questionnaires were used to collect data on demographics and oral hygiene practices. Oral hygiene status using the Oral Hygiene Index Simplified (OHI-S) and renal function using estimated glomerular filtration rate (eGFR) were assessed in both groups. Data collected were analyzed using IBM SPSS Statistics 23.0. Descriptive analysis was carried out for oral hygiene practices. Independent t-test was used to compare means of oral hygiene status and renal function between the two groups. Multivariable linear regression analysis was performed to explain the relationship between renal function and other predictors, and p-value was set at <0.05.

Results: There were 120 pre-dialysis CKD participants in this study. Of these, 82.5% brushed their teeth once daily. The mean OHI-S score was higher in the periodontitis group than the control group (3.48 vs. 1.72, $p<0.01$). The mean eGFR, however, was higher in the control group than the periodontitis group (62.08 mL/min vs. 40.55 mL/min, $p<0.01$). Male participants had significantly higher OHI-S scores compared to females (2.89 vs. 2.22) but lower eGFR than females (46.16 mL/min vs. 58.06 mL/min, $p<0.01$). In multivariable regression, after adjusting for age, gender, hypertension, and oral hygiene, both CKD stage and clinical attachment loss remained significant independent predictors of eGFR ($p < 0.05$).

Conclusion: After adjusting for age, gender, hypertension status, and oral hygiene, both CKD stage and clinical attachment loss emerged as significant independent predictors of eGFR.

Keywords: Oral hygiene practices, periodontitis, estimated glomerular filtration rate, chronic kidney disease

INTRODUCTION

There is an increasing prevalence of chronic kidney disease (CKD) all over the world, and most individuals with chronic kidney disease also present with oral complications.[1-4] An association has been established between chronic kidney disease and periodontitis. Poor oral hygiene is an influencing factor for periodontal disease, and poor periodontal status reported in CKD may also be a result of neglected oral health status.[5] Poor oral health and chronic kidney disease have been linked in several studies.[1,2,5] Oyetola et al.[1] reported a significantly reduced GFR in individuals having periodontal disease. Omotunde et al.[2] also reported that 80% of the CKD participants in their study had poor oral hygiene.

Chronic kidney disease (CKD) is defined as abnormalities of kidney structure or function, present for ≥ 3 months.[6,7] Chronic kidney disease has become a public health problem, evident by its global prevalence and increasing morbidity and mortality, especially in developing countries like Nigeria. Several hospital-based studies in Nigeria put the prevalence of CKD at 1.6–12.4%, with hypertension being one of the top three risk factors.[8-11]The reported prevalence of chronic kidney disease in a university community in Nigeria was between 19.9% and 45.5%.8 The severity of CKD is grouped into five stages based on glomerular filtration rates (GFR).6 The grouping criteria were developed by the National Kidney Foundation as part of its Kidney Disease Outcomes Quality Initiative (NKF KDOQI).[12] Glomerular filtration rate (GFR) is generally accepted as the best overall measure of kidney function in health and disease.[13]

The mechanism of the effect of poor oral hygiene on renal function is still largely unclear. However, periodontal pathogens have been reported to disseminate through the bloodstream, leading to some systemic changes in the body.[14] Some of the implicated organisms include *Porphyromonas gingivalis* and *Tannerella forsythia*. Through hematogenous spread leading to bacteremia, they actively cross the epithelial barrier. Periodontal pathogens invade, adhere to, and proliferate in the coronary endothelial cells, leading to formation of atheroma and impaired vasculature relaxation. Since cardiovascular diseases and CKD share many risk

factors, it can be said that periodontitis will have a similar effect on the vasculature of the kidney. This alteration of the endothelial function of the kidney by the invasion, adherence, and proliferation of the periodontal pathogens results in reduction of renal blood flow and eventually affects kidney function.[15-19] Periodontitis has been associated with worsening renal function, and periodontal status is also regarded as an indicator of the risk of developing chronic kidney disease. Progression of CKD has also been linked with poor oral hygiene.[20,21]

There are many reports on the oral hygiene status of hemodialysis and peritoneal dialysis patients. However, very few have been reported in pre-dialysis patients, especially in developing countries. Therefore, this study investigated oral hygiene status and its implication on the renal function of pre-dialysis chronic kidney disease patients attending a tertiary health care facility in Nigeria.

METHODS

Study Design and Setting: This was a cross-sectional study conducted between June 2019 and December 2020 at the nephrology unit, Department of Medicine, Obafemi Awolowo University Teaching Hospitals Complex (OAUTHC), Ile-Ife, Osun State, Nigeria, among pre-dialysis patients.

Participants: The study comprised consenting, consecutive participants aged 18 years and above who had been diagnosed with chronic kidney disease for at least 3 months and were undergoing conservative management (pre-dialysis patients).

Participants with moderate to severe periodontitis, as evidenced by ≥2 interproximal sites with probing pocket depth (PPD) ≥5 mm on non-adjacent teeth according to the Centers for Disease Control and Prevention and the American Academy of Periodontology classification,[22] constituted the periodontitis group. Those without periodontitis and with good to fair oral hygiene, assessed using the Oral Hygiene Index Simplified (OHI-S) 1964 23 scores, constituted the control group. Smokers and those who consumed alcohol were excluded from the study.

Sample Size: The sample size was determined using the formula for sample size estimation for comparing two means, which gave a total required sample size of 120 participants for the two groups.

Variables

Outcome variables: Oral hygiene status (assessed using OHI-S) and renal function (assessed using estimated glomerular filtration rate [eGFR]).

Independent variables: Demographics (age, sex), oral hygiene practices (tooth brushing frequency, tooth cleaning agent, frequency of change of tooth cleaning aid, and regularity of removal of food impaction), and periodontitis status.

Data Sources and Measurement

Oral hygiene assessment: Self-administered questionnaires were used to collect data on demographics and oral hygiene practices.

Oral hygiene practices assessed included tooth brushing frequency, tooth cleaning agent, frequency of change of tooth cleaning aid, and regularity of removal of food impaction.

Oral hygiene status was assessed using the Simplified Oral Hygiene Index (OHI-S) by Greene and Vermillion (1964).23OHI-S measures the surface area of the tooth covered by debris and calculus. It consists of two components: the Debris Index-Simplified (DI-S) and the Calculus Index-Simplified (CI-S). It uses index teeth 11, 16, 26, 31, 36, and 46. The sum of DI-S and CI-S gives the OHI-S score. OHI-S values range from 0 to 6 and are interpreted as follows:

- Good: 0.0–1.2
- Fair: 1.3–3.0
- Poor: 3.1–6.0

Renal function assessment: Renal function was assessed using the estimated glomerular filtration rate (eGFR). The severity of chronic kidney disease (CKD) was grouped into five stages based on eGFR, according to the National Kidney Foundation Kidney Disease Outcomes Quality Initiative (NKF KDOQI) guidelines (2019):12

- Stage 1: Normal eGFR ≥90 mL/min per 1.73 m² with persistent albuminuria
- Stage 2: eGFR 60–89 mL/min per 1.73 m²
- Stage 3: eGFR 30–59 mL/min per 1.73 m²
- Stage 4: eGFR 15–29 mL/min per 1.73 m²
- Stage 5: eGFR <15 mL/min per 1.73 m² or end-stage renal disease

Periodontitis classification: Moderate to severe periodontitis was defined as ≥2 interproximal sites with probing pocket depth (PPD) ≥5 mm on non-adjacent teeth, according to the CDC-AAP classification.[22]

Bias: Selection bias was minimized by enrolling consecutive eligible participants who met the inclusion criteria. Information bias was reduced through the use of standardized, validated instruments (OHI-S and eGFR) and objective clinical measurements. Smokers and alcohol consumers were excluded to eliminate potential confounding by these known risk factors for both periodontal disease and CKD progression.

Study Size: The calculated sample size was 120 participants (60 per group).

Quantitative Variables: Continuous variables (age, OHI-S scores, eGFR) were analyzed as means and compared between groups. Categorical variables (sex, oral hygiene practices, CKD stage) were analyzed as proportions. OHI-S scores were categorized as good, fair, or poor based on predefined cut-offs. CKD stages were categorized as 1 through 5 based on eGFR values.

Statistical Methods: Data collected were analyzed using IBM SPSS Statistics version 23.0.

Descriptive analysis: Descriptive analysis was carried out for oral hygiene practices, presented as frequencies and proportions.

Bivariate analysis: Independent t-tests were used to compare means of oral hygiene status and renal function between the periodontitis and control groups.
Multivariable analysis: Multivariable linear regression analysis was performed to explain the relationship between renal function and other predictors. The level of statistical significance was set at $p < 0.05$.

Ethical Considerations
The study was approved by the Ethics and Research Committee (ERC) of the Obafemi Awolowo University Teaching Hospitals Complex, Ile-Ife, Osun State, Nigeria (IRB/IEC/0004553). Written informed consent was obtained from all participants prior to their enrollment in the research.

RESULTS
A total of 120 participants were recruited in this study, with their baseline characteristics presented in Table 1. The mean age was significantly higher in the periodontitis group compared to controls (52.17 ± 15.65 years vs. 39.32 ± 15.14 years, $p<0.05$). Similarly, the mean eGFR was lower among participants with periodontitis (40.55 ± 17.16 mL/min vs. 62.08 ± 15.84 mL/min, $p<0.05$). Gender distribution differed between the groups, with more males in the periodontitis group and more females in the control group ($p<0.05$). Hypertension was more prevalent among those with periodontitis (59.4% vs. 40.6%, p=0.016). In addition, longer duration of CKD was associated with periodontitis, as 57.9% of those with CKD for more than a year had the condition compared to 42.1% in the control group (p=0.023). Overall, the findings showed that periodontitis was linked with older age, lower kidney function, male predominance, higher prevalence of hypertension, and longer duration of CKD.

Table 1: Baseline characteristics of participants by group

Variable	Periodontitis	Control	P-value
Age (mean ± SD)	52.17 ± 15.65	39.32 ± 15.14	0.00
eGFR (mL/min) (mean ± SD)	40.55 ± 17.16	62.08 ± 15.84	0.00
Sex			
Male, n (%)	45 (66.2)	23 (33.8)	0.00
Female, n (%)	15 (28.8)	37 (71.2)	
Hypertension			
No, n (%)	19 (37.3)	32 (62.7)	0.016
Yes, n (%)	41 (59.4)	28 (40.6)	
CKD duration			
Less than a year, n (%)	16 (36.4)	28 (63.6)	0.023
More than a year, n (%)	44 (57.9)	32 (42.1)	

The majority of the participants brushed their teeth once daily (82.5%). Participants who brushed once daily were more in the control group compared to the periodontitis group (90.0% vs. 75.0%, respectively). However, the reverse was the case for those who brushed twice daily (25.0% vs. 10.0%, respectively). The number of participants in the periodontitis group that brushed twice daily was higher than the control. This variation was found to be significant (p=0.03) (Table 2).

There was no variation in the tooth cleaning tools used by the participants (p=0.09). Generally, most individuals claimed to clean their teeth with toothbrush and toothpaste, while 12 participants in the periodontitis group claimed to use chewing stick with or without toothpaste compared to only four in the control group (Table 2).
The majority (73.3%) claimed to change their tooth cleaning aid only when necessary, while toothpick was the most utilized aid for removal of impacted food (65.8%). Interestingly, 38 (31.7%) claimed to use broomstick to remove impacted food (Table 2).
Similarly, there was no variation in the frequency of change of cleaning aid and the agent used for removal of food impaction between teeth by the participants (p=0.24 and 0.32, respectively).

Table 2: Oral hygiene practices of Chronic Kidney Disease participants (both test and control groups)

Oral hygiene practices	Periodontitis n (%)	Control n (%)	Total N (%)	P-value
Frequency of brushing				0.03*
Once	45 (75.0)	54 (90.0)	99 (82.5)	
Twice	15 (25.0)	6 (10.0)	21 (17.5)	
Tooth cleaning aid				0.09**
Toothbrush and toothpaste	48 (80.0)	56 (93.3)	104 (86.7)	
Chewing stick and toothpaste	11 (18.3)	4 (6.7)	15 (12.5)	
Chewing stick only	1 (1.7)	0 (0.0)	1 (0.8)	
Frequency of change of cleaning aid				0.24**
Every month	3 (5.0)	8 (13.3)	11 (9.2)	
Every 3 months	6 (10.0)	10 (16.7)	16 (13.3)	
When necessary	48 (80.0)	40 (66.7)	88 (73.3)	
Others	3 (5.0)	2 (3.3)	5 (4.2)	
Removal of food impaction				0.32**
Use of toothpick	38 (63.3)	41 (68.3)	79 (65.8)	
Use of broomstick	21 (35.0)	17 (28.3)	38 (31.7)	
Use of sharp pointed metal	0 (0.0)	2 (3.3)	2 (1.7)	
Others	1 (1.7)	0 (0.0)	1 (0.8)	
*Pearson chi-square; **Likelihood ratio chi-square				

The mean score of the oral hygiene index simplified was significantly higher in the periodontitis group (3.48) than control (1.72) (p<0.01) (Table 3). The estimated glomerular filtration rate (eGFR) was 40.55 mL/min and 62.08 mL/min for the periodontitis and control groups, respectively (p<0.01) (Table 3).

Table 3: Comparison of the mean values of Oral hygiene and Renal function between the periodontitis and control groups

Periodontal parameter	Group	N	Mean	SD	T	P	95% CI	
							Lower	Upper
OHIS Score	Periodontitis	60	3.48	0.85	13.56	<0.01	1.50	2.01
	Control	60	1.72	0.53				
Renal function	Group	N	Mean	SD	T	P	95% CI	
							Lower	Upper
eGFR (mL/min)	Periodontitis	60	40.55	17.16	-7.14	<0.01	-27.49	-15.55
	Control	60	62.08	15.84				
Independent t-test, SD = Standard Deviation; OHIS = Oral Hygiene Index Simplified; eGFR = Estimated Glomerular Filtration Rate								

Generally, the males had significantly higher OHIS scores compared to the females (2.89 vs. 2.22) (p<0.01). However, the males had significantly lower values of eGFR than the females (46.16 mL/min vs. 58.06 mL/min) (p<0.01) (Table 4).

Table 4: Gender comparison of oral hygiene and renal function of Pre-dialysis Chronic Kidney Disease participants

Indices	Gender	N	Mean	SD	T	P
OHI-S Score	Male	68	2.89	1.11	3.39	<0.01
	Female	52	2.22	1.05		
eGFR (mL/min)	Male	68	46.16	19.92	-3.49	<0.01
	Female	52	58.06	17.32		
T = Independent t-test, SD = Standard Deviation; OHIS = Oral Hygiene Index Simplified; eGFR = Estimated Glomerular Filtration Rate						

The regression analysis revealed that among the predictors studied (age, gender, hypertension, CKD stage, and oral hygiene index

simplified), only CKD stage was significantly associated with baseline eGFR ($p < 0.05$). However, CKD stage was determined using eGFR values. This means that the strong negative relationship observed between CKD stage and eGFR is expected, since lower eGFR automatically places a patient in a higher CKD stage. Therefore, this finding reflects the way CKD is classified rather than indicating an independent or a new predictive relationship. In contrast, age, gender, hypertension, and oral hygiene index simplified score did not demonstrate significant predictive effects ($p > 0.05$) (Table 5).

Table 5: Regression Analysis of Factors Influencing Baseline Glomerular Filtration Rate

Model	**Unstandardized Coefficients**	**Standardized Coefficients**	**T**	**Sig.**	**95.0% Confidence Interval**	**Adjusted R^2**		
	B	Std. Error	Beta			Lower Bound	Upper Bound	
(Constant)	108.181	2.680		40.368	.000	102.988	113.483	0.872
Age at last birthday	-.026	.056	-.022	-.460	.647	-.098	.136	
Gender	2.252	1.384	.057	1.627	.107	-1.443	4.163	
Do you have hypertension	-1.117	1.738	-.028	-.643	.522	-4.484	2.265	
CKD stages	-20.372	.867	-.903	-23.506	.000	-21.583	-17.979	
Oral hygiene index simplified score	.443	1.009	.025	.439	.661	-1.556	2.443	
Dependent Variable:								
estimated glomerular filtration rate (mL/min)								

Although oral hygiene status showed a significant association with eGFR in unadjusted analyses, this association was not sustained in the multivariable model. After adjusting for age, gender, hypertension, and oral hygiene, only CKD stage ($\beta = -20.37$, $p < 0.001$) remained a significant independent predictor of eGFR (Adjusted $R^2 = 0.872$).

DISCUSSION

Findings: This study investigated oral hygiene status and its implication on renal function of pre-dialysis chronic kidney disease participants in a tertiary health care facility in Nigeria. More than three-quarters of the participants in the study brushed their teeth once daily. However, the percentage was higher in the group with periodontitis compared to the non-periodontitis group. This was similar to the findings in a study by Soroye et al.[2] who reported poor oral hygiene among CKD participants. Two-thirds of these participants were in the 4th stage of the disease, revealing the possible impact the poor oral health might be having on renal function. The effect of CKD on periodontitis has been linked to poor oral hygiene and increased level of periodontal inflammation reported in many hemodialysis patients due to neglected oral care, especially in end-stage renal disease (ESRD).17 Only about 14% of the participants in their study brushed twice daily, which was similar to the finding in this present study (25% in the periodontitis group). The mean oral hygiene index simplified (OHI-S) in the periodontitis group was twice that of the group without periodontitis. This finding was also similar to that of Soroye et al.[2]where 80% of the participants had poor oral hygiene.

The estimated glomerular filtration rate (eGFR) was used as a marker of renal function in this study. Interestingly, participants without periodontitis had significantly higher mean eGFR compared to those with periodontitis. This further emphasizes the possible burden and impact of poor oral health status on renal status as documented widely in the literature.[4,24,25] Gender comparison of oral hygiene status and renal function of participants showed that the males had worse oral hygiene as well as reduced eGFR, while the females had better oral hygiene and higher eGFR value. This was similar to findings in other studies.[2,26] Soroye et al.[2] reported a male predominance among participants in their study. Abou-Bakr et al.[26] reported a high prevalence of males (62.7%) compared to females (37.3%). Male patients showed a significantly higher prevalence of CKD and frequency rate of end-stage renal disease than those observed in female patients. Lower frequency of daily brushing and shorter duration of brushing,[27] poor oral hygiene habits and less flossing in men, and increased use of tobacco products[28] are some of the possible explanations for that finding.

The focus of our study was on pre-dialysis chronic kidney disease participants as opposed to hemodialysis and peritoneal dialysis patients widely reported in many studies[29-31] The findings in our study may also help to further emphasize the importance of maintaining good oral hygiene and how this may improve the renal function of patients, especially those who are yet to commence dialysis treatment.

The poor oral hygiene recorded in the periodontitis group was expected, as bacterial plaque is the primary etiologic factor for periodontitis, which is driven by a dysregulated host immune response. This finding was supported by previous studies.[1,2,5] Lower

eGFR found in the group with periodontitis in this study is also consistent with findings in previous studies.[2,25,32-34] Parsegian et al.[25] reported a significant association between periodontitis and CKD. They found that individuals with lower eGFR are more likely to have periodontitis and suggested periodontitis as a possible risk factor for CKD. Delbove et al.[32] in a systematic review found a significant improvement in eGFR in CKD patients following intervention, suggesting a potential link between periodontitis and renal function. Miyata et al.[33] also reported a significant association between the prevalence of periodontitis and lower GFR among dialysis patients. Severe periodontitis was reported to be associated with reduced renal function in the same study. These findings make poor oral hygiene (bacterial plaque), which is the primary etiologic factor for periodontitis, a strong potential risk factor for CKD and reduced eGFR. The exact mechanism for this relationship is still unclear, but systemic inflammation has been implicated in several studies.[19,35-37]

Periodontal pathogens invade, adhere to, and proliferate in the coronary endothelial cells, leading to formation of atheroma and impaired vasculature relaxation. Since cardiovascular diseases and CKD share many risk factors, it can be said that periodontitis will have a similar effect on the vasculature of the kidney. This alteration of the endothelial function of the kidney by the invasion, adherence, and proliferation of the periodontal pathogens results in reduction of renal blood flow and eventually affects kidney function.19 Systemic inflammation has been reported as a non-traditional risk factor associated with increased risk of CKD progression in both non-dialyzed and dialyzed CKD patients.[38-40] This emphasizes the need for regular dental check-ups and preventive oral hygiene measures for CKD patients to improve their overall health outcomes.

Implications: Our findings suggest that oral hygiene may possibly influence eGFR as a marker of renal function. Also, the study being among pre-dialysis patients, unlike the widely reported studies among hemodialysis and peritoneal dialysis patients, emphasizes the need for regular dental check-ups and preventive oral hygiene measures among CKD patients at an early stage of the disease.

Trade-Offs (Limitations): The cross-sectional design of the study and the use of self-administered questionnaires introduced the risk of self-reporting bias on oral hygiene practices. The impact on the results is, however, negligible. We depended on clinical histories to rule out potential confounders like hypertension. Being a single-center study and the poor oral hygiene among the periodontitis patients limit generalizability.

Take-Home (Conclusion): After adjusting for age, gender, hypertension status, and oral hygiene, only CKD stage ($\beta = -20.37$, $p < 0.001$) emerged as a significant independent predictor of eGFR. In contrast, age, gender, hypertension, and oral hygiene index were not significant predictors in the fully adjusted model (Adjusted $R^2 = 0.872$).

Expectations for future research: Multi-center longitudinal studies among Nigerians will help to further validate these findings.

Recommendations: Routine dental checks should be incorporated into the renal treatment protocol. Dentists, periodontists, as well as nephrologists should act to increase the dental awareness of all our patients—renal patients inclusive.

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Conflicts of Interest: The authors declare no conflicts of interest.

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