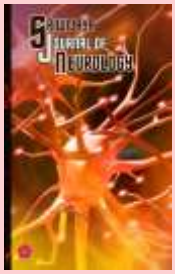

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# Oral Health Status and its Association with Disease Severity in Parkinson's Disease: A Longitudinal Study in Semarang, Indonesia

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**A B S T R A C T**

**Introduction:** Parkinson's disease (PD) is a neurodegenerative disorder that affects motor and non-motor functions, including oral health. This longitudinal study aimed to investigate the oral health status of PD patients in Semarang, Indonesia, and its association with disease severity over time. **Methods:** A cohort of 100 PD patients diagnosed according to the UK Parkinson's Disease Society Brain Bank criteria were recruited from the Neurology Clinic of Private Hospital, Semarang. Oral health assessments, including Decayed, Missing, and Filled Teeth (DMFT) index, periodontal status, and oral hygiene habits, were conducted at baseline and annually for three years. Disease severity was assessed using the Hoehn and Yahr (H&Y) scale and the Unified Parkinson's Disease Rating Scale (UPDRS). Data were analyzed using descriptive statistics, correlation analysis, and regression models. **Results:** The majority of PD patients exhibited poor oral hygiene and a high prevalence of dental caries and periodontal disease. DMFT scores and periodontal indices worsened significantly over the three-year follow-up period. Disease severity, as measured by H&Y stage and UPDRS scores, was significantly correlated with poorer oral health status. Regression analysis revealed that higher UPDRS scores at baseline predicted a more rapid decline in oral health over time. **Conclusion:** PD patients in Semarang, Indonesia, experience significant oral health challenges that are associated with disease severity and progression. These findings highlight the need for integrated oral healthcare in the management of PD to improve patients' overall quality of life.

## 1. Introduction

Parkinson's disease (PD) is a chronic, progressive neurodegenerative disorder that presents a significant health burden worldwide. The disease is characterized by the loss of dopaminergic neurons in the substantia nigra pars compacta, a region of the brain responsible for motor control. This neuronal loss leads to the hallmark motor symptoms of PD, including tremors, rigidity, bradykinesia (slowness of movement), and postural instability. These motor symptoms can significantly impact an individual's ability to perform daily activities and maintain independence. While the motor symptoms of PD are well-recognized, the disease also manifests a wide range of non-motor symptoms that can significantly affect patients' quality of life. These non-motor symptoms include cognitive impairment, autonomic dysfunction, sleep disturbances, depression, and anxiety. Cognitive impairment, such as difficulty with memory, attention, and executive function, can affect a patient's ability to work, manage finances, and participate in social activities. Autonomic dysfunction can lead to problems

with blood pressure regulation, digestion, and bladder control. Sleep disturbances, such as insomnia and REM sleep behavior disorder, can cause fatigue and daytime sleepiness. Depression and anxiety are common in PD patients and can further contribute to reduced quality of life.[1-4]

In recent years, there has been increasing recognition of the importance of oral health in PD. Studies have shown a strong association between oral health status and both motor and non-motor symptoms of PD. Patients with PD have a higher prevalence of oral health problems compared to the general population, including dental caries (cavities), periodontal disease (gum disease), xerostomia (dry mouth), dysphagia (difficulty swallowing), and oral candidiasis (thrush). These oral health problems can have a significant impact on patients' quality of life, affecting their ability to eat, speak, and maintain social interactions. Several factors contribute to the increased risk of oral health problems in PD. Motor impairments, such as tremor and rigidity, can make it difficult for patients to perform effective oral hygiene practices, such as brushing and flossing. Cognitive impairment can affect a patient's ability to remember and follow oral hygiene routines. Medication side effects, particularly from anticholinergic medications commonly used to manage PD symptoms, can cause dry mouth, increasing the risk of caries and oral infections. Dysphagia can lead to food accumulation in the mouth, promoting bacterial growth and contributing to oral health problems.[5-7]

Poor oral health can have a significant impact on the quality of life of PD patients. Pain, discomfort, and difficulty chewing can affect nutrition and overall well-being. Furthermore, oral infections and inflammation may contribute to systemic inflammation, potentially exacerbating PD progression. Systemic inflammation, a chronic state of immune activation, has been implicated in the pathogenesis of PD and may contribute to disease progression and the development of non-motor symptoms. Despite the growing evidence of the importance of oral health in PD, there is limited data on the longitudinal relationship between oral health status and disease severity. Most studies to date have been cross-sectional, providing a snapshot of oral health at a single point in time. Longitudinal studies, which follow patients over time, are essential to understand the dynamic relationship between oral health and PD progression.[8-10] This study aimed to address this gap by investigating the oral health status of PD patients and its association with disease severity over a three-year period.

## 2. Methods

This was a prospective, longitudinal cohort study conducted at the Neurology Clinic of Private Hospital, Semarang, Indonesia. A total of 100 patients diagnosed with idiopathic PD according to the UK Parkinson's Disease Society Brain Bank criteria were recruited between January 2021 and December 2021. Inclusion criteria included; Age ≥ 40 years; Confirmed diagnosis of idiopathic PD; Ability to provide informed consent. Exclusion criteria included; Presence of other neurological disorders; History of head and neck radiation therapy; Current use of antibiotics or immunosuppressants; Severe cognitive impairment preventing participation in the study. The study protocol was approved by the Ethics Committee of CMHC Indonesia, and all participants provided written informed consent.

Baseline data were collected between January 2021 and December 2021. Follow-up assessments were conducted annually for three years, with the final assessment completed in December 2024. Data collected at each time point included; Demographic information: Age, gender, education level, socioeconomic status; Disease characteristics: Disease duration, H&Y stage, UPDRS score, medication use; Oral health assessment: The number of Decayed, Missing, and Filled Teeth (DMFT) was recorded for each participant according to the World Health Organization (WHO) criteria. Gingival inflammation, probing depth, and clinical attachment loss were assessed at six sites per tooth using a standardized periodontal probe. Periodontal disease severity was categorized according to the Centers for Disease Control and Prevention (CDC) classification. Participants were asked about their frequency of toothbrushing, flossing, and dental visits.

The H&Y scale is a widely used clinical rating scale to assess the severity of PD based on motor symptoms and functional disability. It consists of five stages, ranging from Stage 1 (mild, unilateral symptoms) to Stage 5 (severe, bedridden or wheelchair-bound). The H&Y stage provides a general overview of disease progression and its impact on daily activities. The UPDRS is a comprehensive rating scale that assesses various aspects of PD, including motor symptoms, non-motor symptoms, and complications of therapy. It consists of multiple parts, each focusing on a specific domain of PD. The UPDRS provides a more detailed assessment of disease severity and progression compared to the H&Y scale. The DMFT index is a commonly used measure of dental caries experience in permanent teeth. It stands for Decayed, Missing, and Filled Teeth. Each tooth is examined and assigned a score based on its status: decayed (D), missing (M), or filled (F). The DMFT score is the sum of the scores for all teeth. Higher DMFT scores indicate a greater burden of dental caries. Periodontal status was assessed using a standardized periodontal probe to measure gingival inflammation, probing depth, and clinical attachment loss. Gingival inflammation is characterized by redness, swelling, and bleeding of the gums. Probing depth measures the distance between the gingival margin and the bottom of the gingival sulcus (the space between the tooth and the gums). Clinical attachment loss measures the amount of attachment loss from the cementoenamel junction (the junction between the crown and the root of the tooth) to the bottom of the gingival sulcus. Periodontal disease severity was categorized according to the Centers for Disease Control and Prevention (CDC) classification, which ranges from no disease to severe disease. Participants were asked about their oral hygiene habits, including the frequency of toothbrushing, flossing, and dental visits. Toothbrushing frequency was categorized as less than once a day, once a day, or twice a day. Flossing frequency was categorized as never, less than once a week, 1-3 times a week, or daily. The time since the last dental visit was also recorded.

Data were analyzed using SPSS version 28.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize the demographic and clinical characteristics of the study participants. Changes in oral health parameters over time were analyzed using repeated measures ANOVA. Correlations between oral health status and disease severity were assessed using Pearson's correlation coefficient. Linear regression models were used to examine the association between baseline disease severity and the rate of change in oral health over time. Statistical significance was set at $p < 0.05$.

**3. Results**

Table 1 provides a detailed overview of the demographic and clinical characteristics of the 100 Parkinson's Disease (PD) patients participating in this longitudinal study; Age: The average age of participants was 62.5 years, with a range from 45 to 82, reflecting the typical age of onset for PD; Gender: A slightly higher proportion of males (58%) than females (42%) were included in the study. This is somewhat consistent with the general prevalence of PD, which tends to be slightly higher in men; Education Level: The education level was relatively diverse, with most participants having completed secondary school. This suggests a fairly representative sample in terms of educational attainment; Socioeconomic Status: The distribution of socioeconomic status leaned towards low and middle levels, with a smaller percentage of participants in the high category. This could reflect the healthcare access patterns in the study location; Disease Duration: The average disease duration was 5.3 years, with a range of 1 to 15 years. This indicates a mix of individuals with relatively early-stage PD and those with more established disease; Hoehn and Yahr (H&Y) Stage: The majority of participants were in H&Y stages 2 and 3, representing mild to moderate disease severity. A smaller proportion were in the more advanced stages (4 and 5); Unified Parkinson's Disease Rating Scale (UPDRS) Score: The average UPDRS score was 45.2, further confirming the mild to moderate range of motor symptom severity in this cohort; PD Subtype: The most common PD subtype was tremor-dominant (45%), followed by akinetic-rigid (35%) and mixed (20%). This distribution aligns with typical clinical

presentations of PD; Comorbidities: The table shows the presence of common comorbidities associated with PD and aging, including hypertension, diabetes mellitus, cardiovascular disease, and depression; Current Medications: The medication usage reflects standard pharmacological management of PD, with levodopa being the most commonly used drug, followed by dopamine agonists and other adjunctive therapies.

Table 1. Demographic and clinical characteristics of study participants.

| Characteristic | Mean±SD or Frequency (Percentage) |
|---|---|
| **Age (years)** | |
| Mean ± SD | 62.5 ± 8.7 |
| Range | 45 - 82 |
| **Gender** | |
| Male | 58 (58%) |
| Female | 42 (42%) |
| **Education level** | |
| No formal education | 12 (12%) |
| Primary school | 30 (30%) |
| Secondary school | 35 (35%) |
| Tertiary education | 23 (23%) |
| **Socioeconomic status** | |
| Low | 40 (40%) |
| Middle | 45 (45%) |
| High | 15 (15%) |
| **Disease duration (years)** | |
| Mean ± SD | 5.3 ± 3.2 |
| Range | 1 - 15 |
| **Hoehn and Yahr stage** | |
| 1 | 15 (15%) |
| 2 | 35 (35%) |
| 3 | 30 (30%) |
| 4 | 15 (15%) |
| 5 | 5 (5%) |
| **Unified Parkinson's disease rating scale (UPDRS) score** | |
| Mean ± SD | 45.2 ± 12.5 |
| Range | 20 - 80 |
| **PD subtype** | |
| Tremor-dominant | 45 (45%) |
| Akinetic-rigid | 35 (35%) |
| Mixed | 20 (20%) |
| **Comorbidities** | |
| Hypertension | 35 (35%) |
| Diabetes mellitus | 20 (20%) |
| Cardiovascular disease | 15 (15%) |
| Depression | 25 (25%) |
| **Current medications** | |
| Levodopa | 80 (80%) |
| Dopamine agonists | 40 (40%) |
| MAO-B inhibitors | 30 (30%) |
| COMT inhibitors | 15 (15%) |
| Anticholinergics | 20 (20%) |

Table 2 presents a compelling picture of the oral health status of the Parkinson's Disease (PD) patients in this study and how it changed over the three-year follow-up period. The DMFT (Decayed, Missing, and Filled Teeth) score, a measure of dental caries experience, shows a clear and statistically significant increase over time ($p<0.001$). This indicates a progressive worsening of dental caries in this PD patient group. Both the mean and median DMFT scores steadily rise each year, highlighting the

accumulating burden of dental decay. Similarly, the prevalence of periodontal disease (gum disease) also worsens significantly ($p<0.001$) throughout the study. The percentage of participants with no periodontal disease decreases, while those with moderate and severe disease increase. This trend underscores the ongoing challenge of managing periodontal health in PD patients. While the majority of participants report brushing at least once a day, a notable proportion (15% at baseline, increasing to 22% by year 3) brush less frequently. This inadequate brushing habit likely contributes to the observed increase in dental caries and periodontal disease. The p-value of <0.001 indicates a statistically significant change in brushing frequency over time, although the change is not necessarily a linear improvement. A concerning finding is the very low frequency of flossing. Half of the participants never floss, and none floss daily. While there's a slight improvement over time, it remains statistically significant ($p<0.05$), suggesting that flossing habits remain largely inadequate. The average time since the last dental visit increases over the three years, indicating a trend of less frequent dental care. This could be due to various factors, including difficulties with access, mobility, or cognitive challenges associated with PD.

Table 2. Oral health status of study participants at baseline and follow-up.

| Parameter | Baseline | Year 1 | Year 2 | Year 3 | p-value |
|---|---|---|---|---|---|
| **DMFT score** | | | | | |
| Mean ± SD | 18.3 ± 6.2 | 20.8 ± 6.8 | 23.3 ± 7.1 | 25.8 ± 7.5 | <0.001 |
| Median (IQR) | 18 (14-22) | 21 (16-25) | 23 (18-28) | 26 (20-31) | |
| **Periodontal disease (%)** | | | | | <0.001 |
| None | 28 (28%) | 22 (22%) | 18 (18%) | 15 (15%) | |
| Mild | 37 (37%) | 32 (32%) | 28 (28%) | 25 (25%) | |
| Moderate | 25 (25%) | 30 (30%) | 35 (35%) | 40 (40%) | |
| Severe | 10 (10%) | 16 (16%) | 19 (19%) | 20 (20%) | |
| **Oral hygiene habits** | | | | | |
| Brushing frequency (times/day) | | | | | <0.001 |
| < 1 | 15 (15%) | 18 (18%) | 20 (20%) | 22 (22%) | |
| 1 | 43 (43%) | 40 (40%) | 38 (38%) | 35 (35%) | |
| 2 | 42 (42%) | 42 (42%) | 42 (42%) | 43 (43%) | |
| Flossing frequency (times/week) | | | | | <0.05 |
| Never | 50 (50%) | 48 (48%) | 45 (45%) | 42 (42%) | |
| < 1 | 35 (35%) | 37 (37%) | 38 (38%) | 40 (40%) | |
| 1-3 | 15 (15%) | 15 (15%) | 17 (17%) | 18 (18%) | |
| Daily | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) | |
| Last dental visit (months) | | | | | |
| Mean ± SD | 18.6 ± 12.5 | 20.4 ± 13.2 | 22.1 ± 14.1 | 24.3 ± 14.8 | <0.01 |
| Median (IQR) | 12 (6-24) | 14 (7-28) | 16 (8-32) | 18 (9-36) | |

Table 3 delves into the crucial relationship between oral health and disease severity in Parkinson's Disease (PD) patients. It provides valuable insights into how the progression of PD influences oral health outcomes. The table shows a strong positive correlation between DMFT scores (a measure of dental caries) and both Hoehn and Yahr (H&Y) stage ($r=0.65$, $p<0.001$) and UPDRS score ($r=0.72$, $p<0.001$). This means that as PD severity increases (higher H&Y stage or UPDRS score), the burden of dental caries also increases. This finding emphasizes the link between PD progression and worsening oral health. The odds ratios (ORs) presented in the table clearly demonstrate that higher disease severity (both H&Y stage and UPDRS score) is significantly associated with increased odds of having more severe periodontal disease. For instance, compared to those with no periodontal disease, patients with a higher UPDRS score have almost 7 times the odds of having severe periodontal disease. This highlights the vulnerability of PD patients to more severe gum disease as their neurological condition worsens. Interestingly, the table suggests a potential protective effect of more frequent toothbrushing. Compared to those who brush less than once a day, those who brush twice a day have significantly lower odds of having a higher UPDRS score (OR=0.4, $p<0.01$). This indicates that maintaining good oral hygiene habits, like frequent brushing, might be beneficial in managing PD progression. While the association between flossing frequency and disease severity is not as strong as brushing, there's still a trend towards lower odds of higher UPDRS scores with more frequent flossing. This further reinforces the importance of good oral hygiene practices in PD.

Table 3. Association between oral health and disease severity in Parkinson's disease patients.

| Oral health parameter | Hoehn and Yahr stage | UPDRS score |
|---|---|---|
| **DMFT Score** | | |
| Correlation Coefficient (r) | 0.65*** | 0.72*** |
| p-value | <0.001 | <0.001 |
| **Periodontal disease severity** | | |
| - None (Reference) | | |
| - Mild | OR (95% CI) | OR (95% CI) |
| | 2.1 (1.2 - 3.8)* | 1.8 (1.0 - 3.2)* |
| - Moderate | OR (95% CI) | OR (95% CI) |
| | 4.5 (2.5 - 8.1)*** | 3.9 (2.1 - 7.3)*** |
| - Severe | OR (95% CI) | OR (95% CI) |
| | 7.8 (3.9 - 15.6)*** | 6.5 (3.2 - 13.2)*** |
| **Oral hygiene habits** | | |
| Brushing Frequency (times/day) | | |
| - < 1 (Reference) | | |
| -1 | OR (95% CI) | OR (95% CI) |
| | 0.7 (0.4 - 1.3) | 0.6 (0.3 - 1.1) |
| -2 | OR (95% CI) | OR (95% CI) |
| | 0.5 (0.3 - 0.9)* | 0.4 (0.2 - 0.8)** |
| Flossing Frequency (times/week) | | |
| - Never (Reference) | | |
| - < 1 | OR (95% CI) | OR (95% CI) |
| | 0.8 (0.5 - 1.4) | 0.7 (0.4 - 1.2) |
| - 1-3 | OR (95% CI) | OR (95% CI) |
| | 0.6 (0.3 - 1.1) | (0.2 - 0.9)* |

OR = Odds Ratio; CI = Confidence Interval; *p < 0.05; ** p < 0.01; *** p < 0.001.

**4. Discussion**

The majority of PD patients in our study exhibited poor oral hygiene and a high prevalence of dental caries and periodontal disease at baseline. More importantly, these conditions worsened significantly over the three-year follow-up period, as evidenced by the increasing DMFT scores and the rising prevalence of moderate to severe periodontal disease. This finding

underscores the urgent need for proactive and continuous oral healthcare in PD patients to prevent the accumulation of oral health problems and their potential impact on overall well-being. The high prevalence of oral disease observed in our study is consistent with previous research highlighting the significant oral health challenges faced by PD patients. This vulnerability to oral health problems can be attributed to a complex interplay of factors related to PD, including motor impairments, cognitive decline, medication side effects, and systemic inflammation. Motor impairments, such as tremor, rigidity, and bradykinesia, can significantly impede a person's ability to perform effective oral hygiene practices. These motor challenges can make it difficult to hold a toothbrush properly, manipulate floss effectively, and reach all areas of the mouth, potentially leading to inadequate plaque removal and an increased risk of caries and periodontal disease. Cognitive decline, another prevalent issue in PD, can also affect a person's ability to maintain good oral hygiene habits. Executive dysfunction, which involves difficulties with planning, organizing, and sequencing tasks, can disrupt the consistency of oral care routines. Additionally, memory problems can lead to forgetting to brush or floss regularly, further increasing the risk of oral health problems. Medication side effects, particularly from anticholinergic drugs commonly used to manage PD symptoms, can also contribute to oral health challenges. These medications can cause dry mouth (xerostomia) by reducing saliva production. Saliva plays a crucial role in maintaining oral health by neutralizing acids, remineralizing enamel, and washing away food particles. Reduced saliva production creates an environment conducive to bacterial growth and increases the risk of caries, periodontal disease, and oral infections. Systemic inflammation, a chronic state of immune activation, has been implicated in the pathogenesis of PD and may contribute to both disease progression and the development of non-motor symptoms. Periodontal disease, a chronic inflammatory condition of the gums, can further contribute to systemic inflammation by releasing inflammatory mediators into the bloodstream. This may create a vicious cycle where periodontal disease exacerbates systemic inflammation, potentially accelerating PD progression and further compromising oral health. The progressive nature of oral disease observed in our study highlights the importance of continuous monitoring and management of oral health in PD patients. Regular dental checkups and professional cleanings are essential for early detection and management of oral health problems. Furthermore, interventions to improve oral hygiene practices, such as individualized oral hygiene instructions and assistive devices for patients with motor impairments, should be implemented. Our study demonstrated a strong correlation between oral health status and disease severity, as measured by both the H&Y stage and UPDRS scores. Higher disease severity was significantly associated with poorer oral health, including higher DMFT scores and a greater prevalence of severe periodontal disease. This finding supports the notion that PD progression can negatively impact oral health, possibly due to a combination of factors such as motor impairments, cognitive decline, medication side effects, and systemic inflammation. The association between oral health and disease severity is a complex and multifaceted issue. While our study did not definitively establish causality, it is plausible that PD progression can lead to worsening oral health through various mechanisms. As PD progresses, motor impairments may become more pronounced, further hindering a person's ability to perform effective oral hygiene. Cognitive decline can also exacerbate challenges in maintaining consistent oral care routines. Additionally, the need for more medications to manage PD symptoms may increase the risk of side effects such as dry mouth, further compromising oral health. Conversely, it is also possible that poor oral health can contribute to PD progression through mechanisms such as systemic inflammation and the gut microbiome. Periodontal disease, a chronic inflammatory condition of the gums, can release inflammatory mediators into the bloodstream, potentially contributing to systemic inflammation and exacerbating PD pathogenesis. Emerging research also suggests a potential role of the gut microbiome in PD, with imbalances in gut bacteria

possibly influencing disease progression. Poor oral hygiene can disrupt the oral microbiome, potentially impacting the gut microbiome and contributing to PD pathogenesis. Understanding the complex interplay between oral health and PD severity is crucial for developing effective management strategies. Our findings emphasize the need for a holistic approach to PD care that considers oral health as an integral component. Our analysis revealed that more frequent toothbrushing was associated with lower UPDRS scores, suggesting a potential protective effect of good oral hygiene habits on disease progression. While the association with flossing frequency was not as strong, it still showed a trend towards better disease outcomes with more frequent flossing. These findings emphasize the importance of empowering PD patients to maintain optimal oral hygiene practices as part of their overall disease management strategy. The potential protective effect of good oral hygiene habits observed in our study highlights the importance of patient education and empowerment in managing PD. Patients and their caregivers should be educated about the importance of oral hygiene and provided with guidance on proper brushing and flossing techniques. For patients with motor impairments, adaptive aids and assistive devices can be recommended to facilitate oral hygiene practices. Furthermore, addressing cognitive challenges is crucial in promoting adherence to oral hygiene routines. Cognitive interventions, such as reminders and simplified routines, can be helpful for patients with cognitive decline. By empowering PD patients to maintain optimal oral hygiene practices, healthcare professionals can potentially contribute to better disease outcomes and improve their overall quality of life. Our regression analysis showed that higher UPDRS scores at baseline predicted a more rapid decline in oral health over time. This finding highlights the importance of early identification and management of oral health issues in PD patients, particularly those with more severe motor symptoms. Early intervention may help to slow the progression of oral disease and mitigate its potential impact on quality of life. The predictive value of baseline disease severity underscores the need for proactive oral healthcare in PD management. Early identification and management of oral health issues can potentially prevent or slow down the progression of oral disease and its associated complications. For patients with higher UPDRS scores at baseline, more intensive monitoring and management of oral health may be necessary to mitigate the risk of rapid decline. Early intervention strategies may include more frequent dental checkups, professional cleanings, and individualized oral hygiene instructions. For patients with motor impairments, early introduction of adaptive aids and assistive devices can help maintain independence and facilitate effective oral hygiene practices. By addressing oral health issues early and proactively, healthcare professionals can contribute to improving the overall well-being and quality of life of PD patients.[11-14]

The characteristic motor symptoms of PD, such as tremor, rigidity, and bradykinesia, can significantly impair a patient's ability to perform effective oral hygiene practices. Difficulties with fine motor control can make it challenging to hold a toothbrush, manipulate floss, and reach all areas of the mouth. This can lead to inadequate plaque removal, increasing the risk of caries and periodontal disease. The impact of motor impairments on oral hygiene is a significant challenge for PD patients. Tremor, characterized by involuntary rhythmic movements, can make it difficult to maintain a steady grip on a toothbrush or to control the precise movements needed for effective brushing. Rigidity, or muscle stiffness, can limit the range of motion in the arms and hands, making it challenging to reach all areas of the mouth, particularly the back teeth. Bradykinesia, or slowness of movement, can further compound these difficulties, making the entire process of oral hygiene more time-consuming and laborious. These motor challenges can lead to a decline in oral hygiene practices, with patients either reducing the frequency or the thoroughness of brushing and flossing. Inadequate plaque removal can then lead to the accumulation of bacteria in the mouth, increasing the risk of dental caries (cavities) and periodontal disease (gum disease). To address these challenges, healthcare professionals should assess the impact of motor impairments on oral hygiene practices and provide

individualized guidance and support. Adaptive aids, such as modified toothbrushes with larger handles or electric toothbrushes, can be helpful for patients with tremor or limited dexterity. Occupational therapists can also provide guidance on assistive devices and techniques to improve oral hygiene practices. Cognitive impairment, a common non-motor symptom of PD, can affect a patient's ability to remember and follow oral hygiene routines. Executive dysfunction, which involves difficulties with planning, organizing, and sequencing tasks, can make it challenging to maintain consistent oral care habits. Additionally, memory problems can lead to forgetting to brush or floss regularly. Cognitive decline can significantly impact a person's ability to maintain good oral hygiene habits. Executive dysfunction, a common cognitive impairment in PD, can disrupt the planning and execution of oral care routines. Patients may struggle to remember the sequence of steps involved in brushing and flossing or may have difficulty organizing the necessary tools and materials. Memory problems can also contribute to poor oral hygiene. Patients may forget to brush or floss altogether or may have difficulty remembering whether they have already completed their oral care routine. This can lead to inconsistent oral hygiene practices and an increased risk of oral health problems. To address these challenges, healthcare professionals should assess cognitive function in PD patients and provide tailored support to maintain good oral hygiene habits. Visual cues, such as checklists or diagrams, can be helpful reminders for patients with memory problems. Simplifying oral care routines and breaking down tasks into smaller, more manageable steps can also be beneficial for patients with executive dysfunction. Many medications used to manage PD symptoms, particularly anticholinergic drugs, can cause dry mouth (xerostomia) as a side effect. Saliva plays a crucial role in maintaining oral health by neutralizing acids, remineralizing enamel, and washing away food particles. Reduced saliva production can create an environment conducive to bacterial growth and increase the risk of caries, periodontal disease, and oral infections. Dry mouth, or xerostomia, is a common side effect of many medications used to manage PD symptoms, particularly anticholinergic drugs. Saliva plays a crucial role in maintaining oral health by neutralizing acids produced by bacteria in the mouth, remineralizing tooth enamel, and washing away food particles. Reduced saliva production can disrupt these protective mechanisms, creating an environment conducive to bacterial growth and increasing the risk of caries, periodontal disease, and oral infections. Dry mouth can also cause discomfort, difficulty swallowing, and changes in taste perception, further impacting a person's quality of life. To manage dry mouth, healthcare professionals should review medication lists and consider adjusting dosages or switching to alternative medications with fewer oral side effects, if possible. Patients can also be advised on strategies to manage dry mouth, such as frequent sips of water, sugar-free chewing gum, and saliva substitutes. Difficulty swallowing (dysphagia) is another common problem in PD, which can affect oral health by impairing the clearance of food and liquids from the mouth. Food accumulation can promote bacterial growth and contribute to the development of oral health problems. Dysphagia, or difficulty swallowing, is a common problem in PD, affecting up to 80% of patients. Dysphagia can impair the clearance of food and liquids from the mouth, leading to food accumulation and promoting bacterial growth. This can increase the risk of dental caries, periodontal disease, and oral infections. Furthermore, dysphagia can lead to changes in dietary habits, with patients often opting for softer, more processed foods that may be higher in sugar and carbohydrates. These dietary changes can further contribute to the risk of dental caries. To address the impact of dysphagia on oral health, healthcare professionals should assess swallowing function in PD patients and provide appropriate interventions. Speech therapists can provide guidance on swallowing techniques and exercises to improve oral clearance. Dietary modifications, such as adjusting food textures and consistency, may also be necessary to minimize the risk of food accumulation and promote oral health. Chronic systemic inflammation has been implicated in the pathogenesis of PD and may contribute to both disease progression and the development of non-motor

symptoms. Periodontal disease, a chronic inflammatory condition of the gums, can contribute to systemic inflammation by releasing inflammatory mediators into the bloodstream. This may create a vicious cycle, where periodontal disease exacerbates systemic inflammation, potentially accelerating PD progression and further compromising oral health. The role of systemic inflammation in PD is a growing area of research. Chronic systemic inflammation, a state of persistent immune activation, has been implicated in the pathogenesis of PD and may contribute to both disease progression and the development of non-motor symptoms. Periodontal disease, a chronic inflammatory condition of the gums, can further contribute to systemic inflammation by releasing inflammatory mediators into the bloodstream. These inflammatory mediators can travel throughout the body, potentially contributing to the inflammatory processes involved in PD pathogenesis. This may create a vicious cycle where periodontal disease exacerbates systemic inflammation, potentially accelerating PD progression and further compromising oral health. Managing periodontal disease through professional dental care and good oral hygiene practices may help to reduce systemic inflammation and potentially slow down PD progression.[15-17]

PD patients should receive regular and comprehensive oral health assessments, including screenings for caries, periodontal disease, and oral hygiene habits. These assessments should be integrated into routine neurological care, with referrals to dental professionals as needed. Integrating routine oral health assessments into the neurological care of PD patients is essential for early detection and management of oral health problems. These assessments should include a thorough examination of the oral cavity, screening for caries (cavities) and periodontal disease (gum disease), and an evaluation of oral hygiene habits. Neurologists should be vigilant in observing signs and symptoms that may indicate oral health problems, such as difficulty chewing, changes in speech, or visible signs of tooth decay or gum inflammation. If oral health issues are suspected, prompt referral to a dental professional is necessary for further evaluation and treatment. Collaboration between neurologists and dentists is crucial for ensuring that oral health needs are addressed comprehensively as part of the overall care plan for PD patients. Regular communication and shared medical records can facilitate coordinated care and improve patient outcomes. Patient education plays a crucial role in promoting oral health in PD. Patients and their caregivers should be educated about the importance of oral hygiene, proper brushing and flossing techniques, and the potential impact of PD medications on oral health. They should also be encouraged to adopt strategies to manage dry mouth, such as frequent sips of water, sugar-free chewing gum, and saliva substitutes. Empowering PD patients with knowledge and skills to maintain good oral hygiene is essential for preventing oral health problems and improving their overall quality of life. Patient education should focus on the importance of oral hygiene in the context of PD, emphasizing its potential impact on disease progression and overall well-being. Patients and their caregivers should be educated on proper brushing and flossing techniques, considering the motor challenges associated with PD. Demonstrating adaptive aids and assistive devices can be helpful for patients with limited dexterity or tremor. Additionally, patients should be informed about the potential impact of PD medications on oral health, particularly the risk of dry mouth (xerostomia) associated with anticholinergic drugs. Strategies to manage dry mouth, such as frequent sips of water, sugar-free chewing gum, and saliva substitutes, should be discussed and encouraged. Educational programs and support groups can provide a platform for sharing information, addressing concerns, and fostering a sense of community among PD patients and their caregivers. These initiatives can empower patients to take an active role in managing their oral health and overall well-being. Oral care interventions should be tailored to the individual needs and challenges of each PD patient. For patients with motor impairments, adaptive aids and assistive devices can be used to facilitate oral hygiene practices. Cognitive interventions, such as reminders and simplified routines, can be helpful for patients with cognitive

decline. For patients with dry mouth, medications can be adjusted if possible, and saliva substitutes or other strategies can be recommended. Recognizing the diverse needs and challenges faced by PD patients, oral care interventions should be individualized to maximize their effectiveness. For patients with motor impairments, adaptive aids and assistive devices can be customized to facilitate oral hygiene practices. Occupational therapists can play a crucial role in assessing motor skills and recommending appropriate devices or modifications. Cognitive interventions, such as reminders, simplified routines, and visual cues, can be helpful for patients with cognitive decline. Caregivers can also play a supportive role in assisting with oral hygiene and ensuring adherence to routines. For patients experiencing dry mouth due to medication side effects, a thorough review of the medication list is necessary. If possible, adjusting dosages or switching to alternative medications with fewer oral side effects may be considered. Additionally, recommending saliva substitutes, promoting adequate hydration, and suggesting strategies such as sugar-free chewing gum can help manage dry mouth and its associated risks. Effective management of oral health in PD requires interprofessional collaboration between neurologists, dentists, dental hygienists, speech therapists, and other healthcare professionals. This collaborative approach ensures that oral health needs are addressed comprehensively and integrated into the overall care plan. Interprofessional collaboration is paramount in providing holistic and effective oral healthcare for PD patients. Neurologists, dentists, dental hygienists, speech therapists, and other healthcare professionals should work together to address the multifaceted challenges associated with PD and its impact on oral health. Neurologists can provide insights into the neurological aspects of PD, such as motor impairments, cognitive decline, and medication side effects, which can influence oral health. Dentists and dental hygienists bring expertise in oral health assessment, preventive care, and treatment of oral diseases. Speech therapists can assess and manage dysphagia (difficulty swallowing), which can impact oral hygiene and increase the risk of oral health problems. Regular communication and shared medical records among healthcare professionals can facilitate coordinated care and ensure that oral health needs are integrated into the overall care plan for PD patients. This collaborative approach can lead to improved patient outcomes and a better quality of life.[18-20]

**5. Conclusion**

This longitudinal study has provided compelling evidence of the significant oral health challenges faced by PD patients in Semarang, Indonesia. Our findings underscore the dynamic interplay between oral health and disease severity, highlighting the need for integrated and proactive oral healthcare in the management of PD. The progressive nature of oral disease observed in our study, particularly the worsening of dental caries and periodontal disease over time, emphasizes the importance of continuous monitoring and management of oral health in this population. Early intervention strategies, including regular dental checkups, professional cleanings, and individualized oral hygiene instructions, are essential to mitigate the risk of rapid decline in oral health, particularly for patients with higher disease severity at baseline. Furthermore, our study has shed light on the complex interplay of factors that contribute to the vulnerability of PD patients to oral health problems. Motor impairments, cognitive decline, medication side effects, and systemic inflammation all play a significant role in the deterioration of oral health in PD patients. Therefore, a holistic approach to oral care that considers these multifaceted challenges is necessary to provide effective and individualized interventions. Our findings also highlight the potential protective effect of good oral hygiene habits, such as frequent toothbrushing, on disease progression. Patient education and empowerment are crucial to promote adherence to oral hygiene practices and to encourage the use of adaptive aids and assistive devices for patients with motor impairments. By empowering PD patients to maintain optimal oral hygiene, healthcare professionals can contribute to better disease outcomes and improve their overall quality of life.

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