REVIEW PAPERS

Chronic kidney disease and oral health – a review

Przewlekła choroba nerek a zdrowie jamy ustnej – przegląd

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KEYWORDS:

- periodontal disease
- hemodialysis
- chronic renal failure
- dialysis therapy
- caries

ABSTRACT

Chronic kidney disease (CKD) and oral diseases are interrelated, especially in hemodialysis patients who are more susceptible to infections, periodontal diseases, and other dental issues. The increased risk of these conditions is due to metabolic disturbances, dry mouth, immune dysfunction, and side effects of treatment. Periodontal disease negatively impacts CKD management and increases cardiovascular risk. Therefore, the implementation of prevention, diagnosis, and treatment of oral diseases in the treatment plan for CKD patients is essential to improve quality of life and treatment outcomes.

SŁOWA KLUCZOWE:

- choroby przyzębia
- hemodializa
- przewlekła niewydolność nerek
- dializoterapia
- próchnica

STRESZCZENIE

Przewlekła choroba nerek (CKD) i choroby jamy ustnej są wzajemnie powiązane, szczególnie u pacjentów hemodializowanych, którzy są bardziej narażeni na infekcje, choroby przyzębia oraz inne problemy stomatologiczne. Wzrost ryzyka tych schorzeń wynika z zaburzeń metabolicznych, suchości w jamie ustnej, zaburzeń odporności oraz skutków ubocznych leczenia. Choroba przyzębia ma negatywny wpływ na kontrolę CKD, a także zwiększa ryzyko sercowo-naczyniowe. W związku z tym, w planie leczenia pacjentów z CKD, niezbędne jest uwzględnienie profilaktyki, diagnostyki i leczenia chorób jamy ustnej, aby poprawić jakość życia i skuteczność terapii.

Introduction

Chronic kidney disease (CKD) and oral diseases are interrelated. In patients with CKD, especially those undergoing hemodialysis, there is an increased susceptibility to oral infections, a higher amount of biofilm, dental plaque, salivary gland dysfunction, taste disorders, halitosis, and an increased frequency and severity of destructive periodontal diseases. Undiagnosed periodontitis can affect the course of treatment in patients with CKD. Periodontal inflammation may contribute to systemic inflammatory burden, including an elevation of C-reactive protein (CRP) levels. This is particularly important in CKD patients, as arteriosclerotic complications are the leading cause of mortality (1-5).

Epidemiology of dental and periodontal diseases (DPD) in chronic kidney disease (CKD) patients

A thorough analysis of dental and periodontal disease (DPD) epidemiology in chronic kidney disease (CKD) patients highlights their significant impact on health outcomes. According to the World Health Organization (WHO), 30-50% of adults globally experience periodontal diseases (25), with prevalence reaching 47% among adults aged 35-44 and 80-90% in individuals over 65 years (5, 20). CKD patients are at even higher risk, with prevalence ranging from 60-80%, rising to 90% among dialysis patients (13, 17). In CKD stages 3 and 4, the rates reach 70-80%, and severe periodontitis affects more than half of dialysis patients (15, 37). Demographic factors further influence prevalence patterns. Men aged 35-44 face a 1.5 to 2 times higher risk of periodontal disease than women (31). In the U.S., African Americans and Hispanics experience rates of 45-55%, surpassing those observed among white individuals (23). Key risk factors include diabetes, smoking, and age. CKD patients with type 2 diabetes show a periodontal disease prevalence between 60-90% (33). Smoking increases the risk two- to threefold and accounts for 40% of advanced cases (19, 35). Advanced age remains a crucial factor (20).

Oral health impacts of CKD – pathogenesis

Patients with chronic kidney disease may experience various oral changes, including white lichen-like lesions, leukoplakia,

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ISSN 2657-9669/
Published and financed by Centre of Postgraduate Medical Education; https://doi.org/10.36553/wm.169

ulcers, black hairy tongue, hairy leukoplakia, geographic tongue, fungal infections, and papillomatous lesions. Lichen-like changes (OLL) may be directly caused by chronic kidney failure and medications such as diuretics and beta-blockers. Hairy leukoplakia (EBV), papillomas (HPV), and fungal infections may result from immunocompromised conditions (6).

Uremic stomatitis manifests as painful lesions forming white spots (differentiated from oral lichen planus, chronic hyperplastic candidiasis, and hairy leukoplakia), erosions, and ulcers (7). The white lesions most commonly affect the tongue's lateral and ventral surfaces, the mouth's floor, the cheeks, and the area around the molars. Taste disturbances often accompany these symptoms. Microscopic examination shows acanthosis, hyperparakeratosis, and the presence of ballooned keratinocytes in the deeper layers of the epithelium. It is suggested that uremic changes result from the chemical action of ammonia on the mucous membrane of the mouth, which is formed by bacterial urease acting on urea present in saliva. It is suggested that uremic changes result from the chemical action of ammonia on the mucous membrane of the mouth, where ammonia is formed as a result of bacterial urease acting on urea present in saliva. Uremic stomatitis is becoming less common due to better access to treatment for chronic kidney failure. It resists local treatment and recedes once the patient's renal parameters improve (6-10).

Hemodialysis can lead to dry mouth (xerostomia), increasing the risk of dental caries and periodontal diseases. Xerostomia affects approximately 33% of dialysis patients. Reduced saliva production promotes excessive plaque accumulation and leads to gingival inflammation. Individuals undergoing hemodialysis may experience immune system disorders, which increase susceptibility to oral infections, including gingivitis and periodontitis (1-5).

Renal dysfunction often leads to disturbances in bone metabolism associated with secondary hyperparathyroidism. Impaired synthesis of the active form of vitamin D and phosphate retention (hyperphosphatemia and hypocalcemia) results in renal osteodystrophy. Radiologically, in the periodontium, demineralisation of the bones, loss of cortical bone, and the presence (mainly in the mandible) of giant cell tumors leading to bone destruction are observed (11-12).

Periodontal disease has a bidirectional relationship with chronic kidney disease (CKD). CKD exacerbates periodontal deterioration through immune suppression, uremic toxins, and metabolic imbalances (7, 12, 18). Conversely, periodontal inflammation contributes to systemic inflammation, burdening renal function and accelerating CKD progression (13-17). Research indicates that periodontal therapy can improve kidney function markers and reduce systemic inflammation in CKD patients (13-17). Oxidative stress is a critical mechanism linking periodontal disease to CKD. Chronic oral inflammation heightens oxidative stress, accelerating kidney damage (6, 11, 18). Systemic inflammation further worsens outcomes, as elevated markers like C-reactive protein (CRP) and interleukin-6 (IL-6) promote renal deterioration (2, 13, 37). Additionally, periodontal diseases increase cardiovascular risk, contributing to atherosclerosis and endothelial dysfunction-both common complications in CKD patients (4, 38, 39). Microbial dysbiosis also plays a key role. An overgrowth of pathogenic bacteria, such as Porphyromonas gingivalis, Tannerella forsythia, and Treponema denticola, introduces bacterial endotoxins into the bloodstream, triggering immune responses that amplify systemic inflammation and damage renal tissues (5, 16, 17). This interplay of oxidative stress, systemic inflammation, cardiovascular impact, and microbial dysbiosis highlights the complex pathogenesis linking periodontal disease and CKD. Maintaining oral health through regular dental care and hygiene is crucial to mitigating CKD progression and its associated complications (1, 12, 13, 17).

At the center, CKD and periodontal disease are depicted as interlinked, indicating their mutual influence. Arrows illustrate how periodontal inflammation, oxidative stress, microbial dysbiosis, and CKD-related factors contribute to disease progression. Systemic Inflammation: Red arrows show how periodontal disease induces systemic inflammation through markers like CRP and IL-6, which, in turn, exacerbate CKD. Oxidative Stress: Green wavy arrows illustrate how chronic

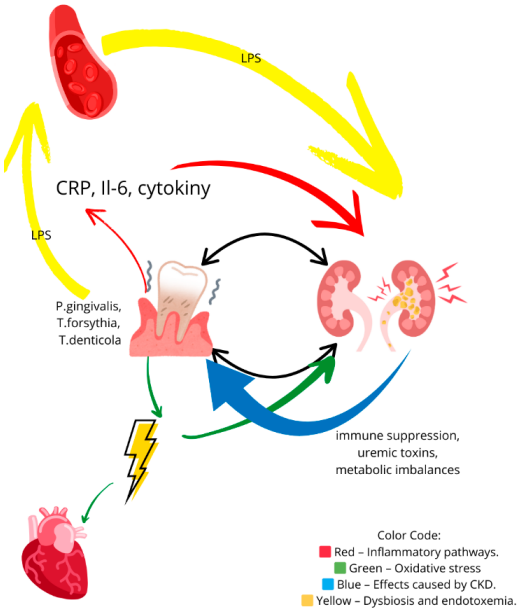

Figure 1. The key pathogenetic mechanisms in the bidirectional relationship between chronic kidney disease (CKD) and periodontal disease.

inflammation from periodontal disease triggers oxidative stress, damaging kidney tissues. An additional path links oxidative stress to cardiovascular complications, indicating shared systemic effects. Microbial Dysbiosis and Endotoxemia: Yellow arrows depict the translocations of oral pathogens (*Porphyromonas gingivalis, Tannerella forsythia, Treponema denticola, Fusobacterium nucleatum, Aggregatibacter actinomycetemcomitans*) into the bloodstream, leading to endotoxemia. Lipopolysaccharides (LPS) from these bacteria damage endothelial cells, activate macrophages, and contribute to kidney fibrosis and dysfunction. CKD Contributing Factors: Blue arrows represent how CKD exacerbates periodontal disease through immune suppression, uremic toxins, and metabolic imbalances, completing the feedback loop.

The following table summarizes major dental and periodontal diseases discussed in this manuscript, highlighting their clinical characteristics and potential links to CKD.

Dental and Periodontal Diseases

The results of previous clinical studies indicate that periodontal disease is a significant health issue in patients with chronic kidney disease. Factors contributing to the accelerated progression of periodontal disease in this population include the presence of uremic toxins, impaired humoral and cellular immunity, anaemia, malnutrition, vitamin D deficiency, hyperparathyroidism, osteoporosis, and other bone metabolism disorders, insulin resistance or diabetes, liver damage due to frequent viral infections, and a general state of disability that impairs oral hygiene care (13). Studies on the prevalence of periodontal disease among adults with chronic kidney disease are limited. In 1985, a study conducted at a Hungarian center in Debrecen revealed periodontal disease in as many as 95% of dialysis patients (14). In the study by Naugle et al. (15) in the southeastern region of Virginia (United States), periodontal disease was found in 100% of hemodialysis patients with an average age of 62. Similar results were obtained at the University Hospital in Valencia, where in 1999 a representative European study was conducted on 105 hemodialysis patients (5). The level of periodontal attachment loss (CAL – clinical attachment loss) was evaluated, and it was found to be significantly higher in the study group compared to the general population (5).

Studies on the oral health status of hemodialysis patients indicate a worse dental condition, advanced periodontal disease, and premature tooth loss compared to the general population. The process of bone tissue degradation in the course of chronic kidney disease and long-term dialysis therapy is significantly more pronounced, especially in

Table: Pathological Dental and Periodontal Diseases in Patients with Chronic Kidney Disease.

Dental and periodontal diseases	Clinical characteristics and potential links to CKD
Periodontal Diseases (gingivitis and periodontitis)	Chronic inflammation of the tissues surrounding the teeth leads to tooth loss. The prevalence of these diseases is higher among CKD patients.
Uremic Stomatitis	Painful lesions in the oral cavity, such as white spots, ulcers, and erosions, are associated with high ammonia levels in the saliva of patients with kidney failure.
Xerostomia (Dry Mouth)	Common among dialysis patients, leading to increased plaque accumulation and a higher risk of dental caries and periodontal diseases.
Taste Disorders (Dysgeusia)	A frequent issue in patients with kidney failure, resulting in altered taste sensation.
Fungal Infections (e.g., Candidiasis)	Due to immunosuppression, CKD patients are more prone to fungal infections in the oral cavity.
Leukoplakia	White patches on the oral cavity's mucous membrane may be related to chronic kidney disease and medications used (e.g., diuretics).
Black Hairy Tongue	A change in the appearance of the tongue, where bacteria and dead cells accumulate on the surface, causing dark discoloration.
Papillomatosis	Warts may grow in the oral cavity and may result from viral infections, such as human papillomavirus (HPV).
Lichen-like Changes	Lichen-like lesions that may result from chronic kidney failure or the use of certain medications.
Radiological Bone Changes (e.g., Renal Osteodystrophy)	Imaging changes in the bones of the periodontium, including bone demineralisation and the presence of giant cell tumors, especially in the mandible.

women who also experience the effects of postmenopausal osteoporosis (16-17).

A Polish study by Wilczyńska-Borawska et al. (18) on a group of 105 hemodialysis patients at the Nephrology and Transplantology Clinic with the Dialysis Center of the Medical University in Białystok identified the factors determining tooth loss in adult hemodialysis patients. The patients were divided into two groups based on the presence or absence of at least two fully functional teeth in at least one dental sextant. The study used multivariate logistic regression analysis. The model included age, gender, education, place of residence, the cause of kidney failure, duration of hemodialysis therapy, smoking, coexisting diabetes, atherosclerotic cardiovascular disease, viral hepatitis, and the cause of tooth loss. Of the eleven demographic and clinical variables, the most significant factor was the younger age of the CKD patients. The risk of tooth loss increases with age. Gender and place of residence were also important predictive factors. The study showed that women on renal replacement therapy had a fourfold lower chance of preserving their teeth than men. Living in rural areas increased the risk of premature tooth loss by six times. It was also demonstrated that smoking was associated with more than a twofold increase in the risk of tooth loss and a fourfold higher probability of edentulism. Therefore, women, rural residents, and smokers among hemodialysis patients require special dental care (18).

The study conducted by Wilczyńska-Borawska et al. (18) aimed to identify factors influencing tooth loss in patients undergoing haemodialysis. A total of 105 patients from the Nephrology and Transplantology Clinic at the Medical University of Białystok were included and divided into two groups: those with at least two functional teeth in one dental quadrant and those with complete tooth loss. The analysis, employing logistic regression, revealed that the most significant risk factor for tooth loss was the patient's age – the risk increased with age. Gender and place of residence were also identified as important factors. Women had a fourfold lower chance of retaining their teeth than men, while patients living in rural areas were six times more likely to lose their teeth than those residing in urban regions. Furthermore, smoking was associated with more than a twofold increase in the risk of tooth loss and a fourfold higher risk of complete tooth loss. The findings of the study underscore the need for specialised dental care for haemodialysis patients, particularly for those in higher-risk groups, such as women, smokers, and individuals living in rural areas (18).

The development of dental caries progresses more rapidly in patients with chronic kidney disease due to impaired salivary secretion, increased salivary viscosity, and even xerostomia (19). This promotes the development of bacterial biofilm. Additionally, elevated urea levels in saliva contribute to increased pH, accelerating the mineralisation of dental plaque and making it more difficult to maintain oral hygiene (20). Numerous studies have shown that patients with chronic kidney disease tend to experience an increase in the number of teeth extracted and a decrease in the number of filled teeth (21-23).

Quality of life and systemic complications

A major issue among adults with chronic kidney disease is the loss of chewing function and early edentulism. This may result from a lack of proper and timely prosthetic care, financial limitations, poor tolerance of removable prosthetic appliances due to xerostomia, fungal infections, and prosthetic stomatopathy, as well as depression, which is exacerbated by living with a chronic illness (24). It should be noted that according to the WHO, the function of life is considered preserved when there are occlusal contacts in at least 20 natural teeth or their prosthetic replacements, such as bridges, crowns, implants, or dentures (25).

Studies by Kalender et al. (24, 26) have shown that over 50% of patients treated for chronic kidney disease suffer from depression. A restrictive diet, health complications, reliance on dialysis machines for patients undergoing dialysis, and a lack of belief in the effectiveness of long-term treatment contribute to a diminished quality of life for patients and may lead to disengagement from dental treatment and caries prevention. Research conducted on 105 hemodialysis patients at a university centre in northeastern Poland found that more than 70% of patients had not restored chewing function, with caries and its complications cited as the primary cause of tooth loss (18).

The kidneys play an essential role in insulin metabolism. In patients with chronic kidney disease, as the condition progresses, insulin resistance and hyperinsulinemia develop, which not only leads to abnormal glucose metabolism but also contributes to the development of hypertriglyceridemia and hypertension, which, in turn, significantly impact cardiovascular risk (27). On the other hand, diabetes currently stands as the leading cause of end-stage renal disease requiring renal replacement therapy. The coexistence of diabetes, as in the general population, adversely affects the survival of dialysis patients (28). Studies conducted in the past decade have highlighted the link between the inflammatory process caused by periodontal diseases and the progression of systemic diseases, including diabetes (29-32). Additionally, it has been demonstrated that diabetes, particularly poorly controlled, has a detrimental effect on oral health. In the course of diabetes, numerous pathological changes occur within the oral cavity, such as progressive periodontal inflammation, taste disturbances, reduced salivation, enlargement and degeneration of salivary glands, atrophic stomatitis, fungal infections, and dental caries (29-32). Hyperglycemia increases glucose levels in both saliva and gingival fluid (29-32). Many authors emphasise certain mechanisms present in diabetes that may modulate the course of periodontal diseases (periodontopathies) (29-33). Among the mechanisms that may modulate the course of periodontal inflammatory diseases in diabetes are genetic influences, the effect of advanced glycation end products (AGEs) on macrophage receptors, specific bacterial flora, impaired neutrophil function (chemotaxis, phagocytosis, bacteriostasis), changes in collagen metabolism, microangiopathies, and alterations in salivary parameters (34-35).

It has also been proven that an active inflammatory state of the periodontium not only hinders the control of diabetes but also complicates the treatment of chronic kidney disease by increasing the concentration of C-reactive protein (CRP), reducing haemoglobin levels, and the presence of bacterial lipopolysaccharides (LPS) from the oral biofilm in the blood, as well as increasing pro-inflammatory cytokines in the body. These parameters also significantly elevate cardiovascular risk (36). Studies show that non-surgical treatment of periodontal disease in hemodialysis patients improves their condition, reduces CRP levels and erythrocyte sedimentation rate (ESR), and positively affects haemoglobin concentration and hematocrit values (37-39).

Conclusions

The findings in the literature over the past 30 years regarding the oral health of hemodialysis patients indicate that oral inflammatory diseases are more prevalent in this group than in the general population, and periodontal inflammation hinders disease control. Furthermore, the association between poor dental health and/or edentulism and the presence of diabetes or cardiovascular diseases in these patients highlights the necessity for specialised and early dental examinations for these individuals. Hemodialysis patients are at increased risk of dental caries, oral mucosal diseases, and periodontopathies compared to the general population, and these conditions progress more rapidly, are more aggressive, and lead to premature loss of the stomatognathic system's functions (34-35).

Due to the growing population of individuals with chronic kidney disease, it is necessary to include the prevention, diagnosis, and treatment of periodontal disease in the therapeutic plan.

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