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TECHNOLOGIES SUPPORTING ORAL HEALTH IN PATIENTS WITH PARKINSON'S DISEASE: CURRENT SOLUTIONS AND FUTURE POSSIBILITIES. A NARRATIVE REVIEW

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ABSTRACT

Parkinson's disease (PD) is associated with progressive motor and non-motor impairments that substantially compromise oral self-care and contribute to poor oral health outcomes. Although conventional preventive strategies have been established, they remain largely static and insufficiently adapted to disease progression or individual patient needs. This narrative review aimed to examine current and emerging technologies that may support oral healthcare in individuals with PD and to identify future directions for technology-assisted dental care.

A narrative literature review was conducted using PubMed/MEDLINE, Scopus, Web of Science, and the Cochrane Library. Relevant publications addressing oral health, Parkinson's disease, assistive technologies, digital health, teledentistry, wearable sensors, and mobile health applications were identified and synthesized qualitatively.

The available technologies were grouped into four domains: functional compensation technologies, behavioral and cognitive support systems, monitoring and feedback technologies, and integrated digital health platforms. Current evidence indicates that assistive devices, wearable sensors, smartphone-based applications, and telemedicine platforms may improve functional independence, behavioral adherence, and remote healthcare delivery. However, most technologies were developed for general Parkinson's disease management rather than for oral healthcare, resulting in predominantly indirect benefits for oral hygiene. A substantial gap remains between motor function monitoring and technologies providing direct support for daily oral hygiene practices.

Future research should prioritize the development of integrated, patient-centered digital platforms combining neurological monitoring, teledentistry, caregiver support, and personalized oral hygiene interventions. Such multidisciplinary approaches may improve oral health outcomes and quality of life in the growing population of individuals living with Parkinson's disease.

KEYWORDS

Parkinson’s Disease, Oral Hygiene, Assistive Technology, Digital Health, Teledentistry, Neurodegenerative Disorders

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1. Introduction

Parkinson’s disease (PD) is a progressive neurodegenerative disorder characterized by the loss of dopaminergic neurons in the substantia nigra and the accumulation of misfolded α-synuclein (Agliardi & Guerini, 2025). These neuropathological changes result in a broad spectrum of motor and non-motor symptoms (table no. 1) that significantly impair daily functioning, including the ability to perform adequate oral self-care (Pardo et al., 2024).

Table 1. Motor and non-motor symptoms of Parkinson’s Disease (Pardo et al., 2024).

Motor symptoms	Non-motor symptoms
1. bradykinesia; 2. resting tremor; 3. rigidity; 4. postural instability; 5. difficulty in walking	1. neuropsychiatric dysfunctions: a. depression; b. dementia c. apathy

Evidence indicates that individuals with Parkinson’s disease (PD) exhibit significantly poorer oral health compared to healthy populations. This is reflected in higher levels of dental plaque accumulation, an increased prevalence of periodontal disease, and a greater rate of tooth loss (van Stiphou et al., 2018).

Multiple factors contribute to this deterioration, including both motor and non-motor impairments. Motor symptoms, such as bradykinesia and tremor, limit the ability to perform effective oral hygiene practices.

Non-motor symptoms, including apathy and depression, may reduce motivation and adherence to daily self-care routines, leading to decreased attention to oral hygiene or less thorough performance of these activities (van Stiphou et al., 2018).

In addition, disturbances in salivary flow, ranging from hyposalivation to sialorrhea, may further exacerbate oral health problems. Hyposalivation may be influenced by pharmacological treatments commonly used in the management of PD. In contrast, sialorrhea is typically associated with impaired swallowing rather than increased saliva production and is commonly linked to dysphagia in patients with PD (Guan et al., 2026).

Taken together, the deterioration of oral health in patients with PD is multifactorial in origin. As a result, these patients require a comprehensive and interdisciplinary approach to care, including tailored dental management strategies. Moreover, the global population is aging, which may lead to increased number of PD and other dementia states diagnoses in the near future (Beard et al., 2016; Pang et al., 2019). That might impact medical care since the number of qualified caregivers is limited. Recent advances in medicine and dentistry suggest that emerging technologies may offer meaningful opportunities to enhance the quality of care provided to this population.

The aim of this paper is to provide an overview of current technological solutions and to explore how innovations used in general medicine and dentistry may be applied to improve oral healthcare in patients with Parkinson's disease.

2. Materials and methods

This study was conducted as a narrative review aimed at providing a comprehensive overview of currently available technologies that may support oral healthcare in patients with Parkinson's disease (PD). Owing to the interdisciplinary nature of the topic, encompassing neurology, dentistry, rehabilitation, and digital health, a narrative approach was considered the most appropriate to synthesize diverse sources of evidence and identify emerging concepts, knowledge gaps, and future research directions.

A literature search was performed using the electronic databases PubMed/MEDLINE, Scopus, Web of Science, and the Cochrane Library. Publications available up to May 2026 were considered.

Search terms combined controlled vocabulary (where applicable) and free-text keywords related to three main concepts: (1) Parkinson's disease ("Parkinson's disease", "Parkinsonism"), (2) oral health ("oral hygiene", "oral health", "dental care", "periodontal disease"), and (3) digital and assistive technologies ("assistive technology", "digital health", "mHealth", "telemedicine", "teledentistry", "wearable sensors", "virtual reality", "rehabilitation technology"). Boolean operators (AND, OR) were used to combine the search terms.

Additionally, the reference lists of relevant articles and systematic reviews were manually screened to identify further publications of potential relevance.

Because this review was narrative in nature, no formal systematic review protocol or PRISMA methodology was applied. Publications were selected based on their relevance to the objective of the review, namely the role of technological solutions in supporting oral healthcare or functional independence among individuals with Parkinson's disease.

Priority was given to systematic reviews, meta-analyses, randomized clinical trials, observational studies, and landmark publications describing digital health technologies applicable to Parkinson's disease. Studies addressing oral healthcare directly were preferentially included; however, evidence regarding technologies that may indirectly improve oral hygiene through enhancement of motor or cognitive function was also considered.

Editorials, conference abstracts without full-text availability, and publications unrelated to the scope of the review were excluded.

The identified evidence was analyzed qualitatively and synthesized narratively. The included technologies were grouped according to their principal mechanism of supporting oral healthcare into four conceptual domains:

1. Functional compensation technologies;
2. Behavioral and cognitive support systems;
3. Monitoring and feedback technologies;
4. Integrated digital health platforms.

This conceptual framework was developed by the authors to facilitate discussion of the current state of knowledge and to identify potential future directions for technological innovation in oral healthcare for patients with Parkinson's disease.

3. Results

3.1 Conventional Oral Hygiene Management

Conventional oral hygiene management in patients with Parkinson's disease is largely shaped by functional limitations affecting daily self-care. Due to motor impairments, patients often experience significant difficulties in performing effective toothbrushing and interdental cleaning, leading to increased accumulation of dental biofilm and a higher risk of oral diseases (Batista et al., 2015; Verhoeff et al., 2023). Evidence-based recommendations emphasize twice-daily toothbrushing with fluoridated toothpaste, preferably using soft or electric toothbrushes, along with regular professional dental care and individualized preventive protocols (Martimbianco et al., 2021).

3.2 Technological approaches supporting oral health in Parkinson's Disease

Technological approaches supporting oral hygiene in Parkinson's disease (PD) can be classified into four interrelated domains: functional compensation technologies, behavioral and cognitive support systems, monitoring and feedback infrastructures, and integrated digital health platforms. Together, these form a continuum from direct task assistance to system-level healthcare coordination aimed at mitigating the impact of motor and non-motor symptoms on oral self-care.

3.2.1 Functional Compensation Technologies

Technologies addressing motor impairment in Parkinson's disease (PD) contribute to oral health maintenance by targeting the functional limitations that directly compromise daily oral hygiene performance. PD-related symptoms such as tremor, bradykinesia, and rigidity significantly impair manual dexterity required for effective toothbrushing and interdental cleaning, leading to increased risk of inadequate plaque control (Verhoeff et al., 2023).

Functional compensation technologies primarily operate at the level of task execution. Assistive oral hygiene strategies, including powered toothbrushes, ergonomically modified handles, and adapted oral care tools, are commonly recommended to reduce fine motor demands and improve grip stability, thereby enabling patients with reduced motor capacity to maintain basic oral hygiene routines (Auffret et al., 2021). In some cases, these approaches are supported by structured hygiene instruction to further optimize technique. However, these interventions remain largely static and do not adjust to fluctuations in motor performance or disease progression.

There are rehabilitation technologies that aim to improve motor function in Parkinson's disease (PD), thereby enhancing patients' ability to perform activities of daily living, including self-care tasks such as oral hygiene. Interventions that improve motor performance may indirectly support oral health maintenance by enhancing functional independence.

Interactive and technology-assisted rehabilitation approaches, particularly virtual reality (VR)-based systems, have demonstrated benefits in improving motor performance, balance, and patient engagement in individuals with PD. Evidence from systematic reviews indicates that VR-based rehabilitation can improve gait, postural control, and motor function through immersive, task-oriented training paradigms (Dockx et al., 2016). These systems enhance patient motivation by providing enriched sensory feedback and structured motor tasks, which may improve adherence to long-term rehabilitation programs.

Beyond specific interventions, broader analyses of technology in PD emphasize the growing role of digital health tools, wearable devices, and integrated technological systems in rehabilitation and disease management. These technologies enable more objective monitoring of motor performance, enhance feedback mechanisms, and support personalized therapeutic approaches (Espay et al., 2016). Collectively, they represent a shift toward technology-assisted, patient-centered rehabilitation models.

Although these rehabilitation technologies are not designed specifically for oral hygiene, improvements in balance, coordination, and fine motor control may indirectly enhance patients' ability to perform effective oral self-care. As motor impairment is a key determinant of inadequate oral hygiene in PD, rehabilitation strategies that improve functional independence may contribute to better oral health outcomes.

3.2.2 Behavioral and Cognitive Support Systems

Cognitive and behavioral impairments in Parkinson's disease (PD), including executive dysfunction, memory deficits, reduced attention and apathy, represent major barriers to maintaining consistent oral hygiene routines alongside motor dysfunction. These non-motor symptoms reduce initiation of self-care behaviors, impair adherence to daily routines, and increase reliance on caregivers, all of which negatively affect health-related outcomes (Verhoeff et al., 2023; Pardo et al., 2024).

Technological interventions addressing these challenges primarily focus on supporting behavioral regulation and improving adherence through digital reinforcement strategies. Mobile health (mHealth)

technologies represent the most widely implemented approach, typically incorporating reminder systems, structured self-management tools, and educational prompts designed to reinforce daily health behaviors. Evidence from randomized studies in PD demonstrates that smartphone-based self-management platforms can enhance patient engagement and support treatment adherence by providing structured digital guidance and facilitating continuous interaction with healthcare routines (Lakshminarayana et al., 2017).

More broadly, meta-analytic evidence across healthcare systems indicates that mobile health interventions can improve service delivery and patient adherence by promoting structured behavioral reinforcement and supporting self-management processes in chronic disease populations (Free et al., 2013). These findings support the applicability of mHealth approaches in PD, where maintaining consistent self-care behaviors, including oral hygiene, is often compromised by both cognitive and motor limitations.

3.2.3 Monitoring and Feedback Technologies

Monitoring and feedback technologies play an increasingly important role in Parkinson's disease (PD) management by enabling objective, continuous assessment of motor symptoms and supporting self-management in daily life. Their relevance to oral health is particularly important given evidence that poorer oral health outcomes are associated with greater disease severity in PD, where increasing motor and functional impairment further limits effective self-care performance (Verhoeff et al., 2023). Although these systems are not specifically designed for oral hygiene applications, their ability to quantify motor performance and reinforce behavioral adherence has important indirect implications for maintaining oral hygiene, which is strongly dependent on both motor and cognitive function.

At this point we come back to wearable sensor technologies for a while, since they represent the most established approach for objective monitoring of PD motor symptoms. Systems based on accelerometers and inertial measurement units allow continuous quantification of tremor, bradykinesia, gait disturbances, and movement variability in real-world environments, providing more ecologically valid data than traditional clinical assessments (Del Din et al., 2016). Such free-living monitoring approaches have demonstrated that motor symptoms in PD fluctuate significantly across daily contexts, supporting the need for continuous rather than episodic assessment of disease severity.

In parallel, smartphone- and wearable-based technologies have expanded digital monitoring into home environments, enabling longitudinal tracking of functional performance outside clinical settings. Large-scale mobile health studies have shown that smartphone systems can reliably capture motor symptoms in real-world conditions and provide continuous functional assessment, supporting decentralized models of care (Bot et al., 2016). These systems generate digital biomarkers that reflect daily functional capacity and may indirectly indicate limitations affecting self-care activities, including oral hygiene performance.

Collectively, monitoring and feedback technologies facilitate a transition from episodic clinical evaluation to continuous, real-world digital monitoring. By integrating objective motor assessment with behavioral feedback mechanisms, these systems enable more personalized and adaptive approaches to disease management. Importantly, their role becomes increasingly relevant as disease severity progresses, since worsening motor impairment is associated with reduced ability to maintain adequate oral hygiene, highlighting the need for earlier identification and support of functional decline. However, despite these advantages, their impact on oral health remains indirect, as current technologies are not specifically designed to support oral hygiene behaviors in PD populations.

3.2.4 Integrated and System-Level Technologies

Integrated digital health platforms represent the highest level of technological support, combining communication, monitoring, and care coordination. Teledentistry systems enable remote consultation, screening, and preventive care delivery, improving access to dental services for individuals with mobility limitations (Gurgel-Juarez et al., 2022; Estai et al., 2018).

Mobile health–based oral health platforms further support adherence through behavioral reinforcement, reminders, and educational interventions (Fernández et al., 2021). At a broader level, digital health systems integrate telemedicine, electronic health records, and decision-support tools to facilitate coordinated care delivery across healthcare providers (Jampani et al., 2011).

More generally, mHealth technologies have demonstrated the ability to improve healthcare delivery processes and patient engagement across chronic disease populations (Free et al., 2013). However, despite these advancements, most integrated systems remain non-specific to Parkinson's disease and do not yet incorporate motor and cognitive impairment data into oral health–focused care pathways.

4. Discussion

This narrative review highlights that maintaining oral health in patients with Parkinson's disease remains a significant clinical challenge despite increasing awareness of disease-specific oral complications. The available evidence demonstrates that technological innovations have the potential to improve several determinants of oral health; however, most currently available solutions were originally developed for general Parkinson's disease management rather than for oral healthcare. Consequently, their influence on oral hygiene is predominantly indirect and mediated through improvements in motor performance, behavioral adherence, or healthcare accessibility rather than through direct assistance with oral hygiene procedures (Espay et al., 2016).

One of the principal findings of this review is the discrepancy between advances in digital medicine and the relatively limited innovation in assistive oral hygiene technologies. While wearable sensors, smartphone applications, and telemedicine platforms have substantially transformed neurological monitoring and rehabilitation, comparable progress has not occurred in technologies specifically supporting daily oral hygiene. Current recommendations for patients with Parkinson's disease continue to rely primarily on powered toothbrushes, adapted handles, caregiver assistance, and individualized preventive dental care (Martimbianco et al., 2021; Verhoeff et al., 2023). These interventions remain valuable but are largely static and cannot respond dynamically to fluctuations in motor function, disease progression, or changing cognitive status.

The findings also suggest that future technological development should move beyond isolated devices toward integrated digital ecosystems. Rather than considering rehabilitation technologies, wearable monitoring, mHealth applications, and teledentistry as independent interventions, these systems could be combined into personalized care pathways. For example, continuous assessment of tremor or bradykinesia obtained from wearable sensors could trigger individualized reminders for oral hygiene at periods of optimal motor function, notify caregivers when functional decline is detected, or facilitate remote dental consultations when deteriorating self-care is suspected. Such integration would shift oral healthcare from a reactive model toward preventive, personalized management.

Another important consideration concerns the practical implementation of digital technologies in an aging Parkinson's disease population. Although digital health solutions offer considerable promise, their adoption may be limited by cognitive impairment, reduced digital literacy, visual dysfunction, depression, and socioeconomic barriers (Kruse et al., 2020; Foster & Sethares, 2014). Consequently, future technology-assisted oral healthcare systems should not only integrate neurological monitoring, teledentistry, and behavioral support but also account for the digital health literacy of patients with Parkinson's disease. As emphasized by Esper et al., limited digital health literacy may reduce patients' ability to effectively use telehealth services, wearable sensors, and smartphone applications. Therefore, future oral healthcare technologies should prioritize intuitive interfaces, caregiver involvement, and user-centered design to maximize accessibility and long-term adoption (Esper et al., 2024).

Importantly, the quality of available evidence remains limited. Much of the current literature evaluates feasibility, usability, or motor outcomes rather than oral health endpoints such as plaque accumulation, periodontal status, caries incidence, or oral health–related quality of life. Furthermore, most studies include relatively small patient populations and short follow-up periods, limiting the strength of clinical recommendations. Well-designed prospective clinical trials evaluating oral health outcomes should therefore represent a priority for future research.

This review has several limitations. As a narrative review, it was not designed to systematically evaluate study quality or perform quantitative synthesis. The included literature encompasses heterogeneous study designs addressing diverse technologies, many of which were not specifically developed for oral healthcare in Parkinson's disease. Therefore, several conclusions are necessarily based on indirect evidence and extrapolation from broader digital health and neurological rehabilitation research.

Overall, the present review suggests that the greatest unmet need is not the development of additional monitoring technologies, but rather the integration of existing digital innovations into comprehensive oral healthcare pathways tailored to Parkinson's disease. Bridging this gap may represent one of the most promising directions for improving oral health and quality of life in this growing patient population.

5. Conclusions

A substantial gap still exists between conventional assistive solutions for oral hygiene and emerging digital technologies. At present, these approaches have not been integrated into cohesive systems that combine motor function rehabilitation, real-time patient monitoring, and direct support for performing oral hygiene procedures. Furthermore, there remains a lack of telemedicine systems specifically tailored to the unique clinical profile of patients with Parkinson's disease. This highlights an important direction for future development in Parkinson's disease care, in which assistive oral hygiene technologies could be integrated with telemedicine platforms to enable neurological monitoring, dental care, and functional support within a unified, patient-centered care system.

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