

## Systematic Review

# Effectiveness of prosthodontic intervention in patients with Parkinson's disease

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## ABSTRACT

**Background:** Oral health plays a crucial role in maintaining the general health of an individual. Parkinson disease (PD) has known to disrupt the oral functions. Prosthetic rehabilitation can be done in these patients. However, there is scarcity of literature to assess the effectiveness or impact of rehabilitation with prosthesis either fixed or removable on various oral functions and quality of life (QoL) or satisfaction of PD patients. The purpose of this systematic study was to assess the effectiveness of prosthodontic rehabilitation in patients with PD.

**Materials and Methods:** The literature search was conducted in the PubMed and CINAHL database for the articles till 2024 in English language. An exploration of gray literature was also included through Google Scholar. Manual search in the references of the selected articles was also done for relevant articles. The methodological quality assessment of cohort studies was done using Newcastle–Ottawa quality assessment form for Cohort Studies (NOS). Assessment of cross-sectional studies was done using the Appraisal tool for Cross-Sectional Studies (tool) and assessment of case series was done using JBI critical appraisal tool for case series.

**Results:** A total of 6 articles were selected from PubMed, 1 from CINAHL, and 2 from Google Scholar. Four articles studied the masticatory efficiency. Oral perception and motor ability were analyzed in two articles. Oral Health QoL was assessed in four articles. One article studied the electromyographic activity.

**Conclusion:** Based on this systematic review, it can be suggested that prosthetic rehabilitation using fixed or removable prosthesis offer potential benefits in PD patients improving the oral functions and QoL. However, there is a dearth of long-term research on evaluation of impact of prosthetic rehabilitation in improving the oral function and QoL of PD patients.

**PROSPERO Registration:** CRD42024570296.

**Key Words:** Dental prosthesis, orofacial dysfunction, Parkinson disease

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## INTRODUCTION

Parkinson's disease (PD) is a complex multisystem neurodegenerative disorder with onset in the fifth

or sixth decade of life.<sup>[1]</sup> PD related physiological changes can impair bodily functions and balance as

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well as induce changes in the stomatognathic system.<sup>[2]</sup> There appear to be multiple ways in which PD impairs orofacial functions. There is a decrease in both jaw movement velocity and mobility. The chewing process and the production and positioning of the food bolus are complicated by the stiffness, decreased movement, and tremor.<sup>[3]</sup> It can affect voluntary and automatic movement leading to pharyngeal motor abnormalities that are a prominent cause of dysphagia, resulting in weight loss and a decreased standard of life.

Multiple oral health concerns, such as xerostomia, burning mouth syndrome, and poor oral hygiene, are encountered by individuals with PD. Poor oral hygiene exacerbates caries, plaque and food debris accumulation leading to poor periodontal health, tooth loss and negative impact on masticatory efficiency.<sup>[1]</sup> Severe tooth loss has been shown to be significantly prevalent among people with PD in literature.<sup>[4]</sup> Apart from the reduced efficacy to carry out daily oral hygiene practice, the majority of PD patients follow a drug regimen, which may worsen their oral health since it alters the quantity and quality of saliva secreted, aggravating oral problems and/or hastening their progression.<sup>[4]</sup>

Studies have shown that in moderate and advanced PD, mastication, and orofacial function are compromised, and as the disease progresses, the severity of the dental and orofacial issues increases.<sup>[3]</sup> Another study concluded that higher number of masticatory cycles was required to chew and ingest food in the PD group than the non-PD group suggesting disruption in the orofacial myofunctional characteristics.<sup>[5]</sup> These disruptions contribute to weight loss, and increased risk of malnutrition affecting their quality of life (QoL).<sup>[6]</sup> For these people to regain their masticatory efficiency and improve QoL, oral rehabilitation with fixed or removable prosthesis (RP) is essential. However, the inability to control the orofacial-pharyngeal muscles, both voluntarily and involuntarily, makes oral rehabilitation more difficult by aggravating issues including, chin and mouth tremors, and difficulty with mastication.<sup>[1]</sup>

Past reviews have presented impact of PD on general oral health. There is only one review that evaluated the impact of oral rehabilitation in PD patients but it studied only the influence on QoL of PD patients and not on other significant parameters. Furthermore, only complete denture was used for rehabilitation in the articles included in this review.<sup>[7]</sup>

However, to the best of the author's knowledge, no review has been done to assess the effectiveness or impact of rehabilitation with prosthesis either fixed or removable on various oral functions and QoL or satisfaction of PD patients. Hence, this systematic review was planned with intention of analyzing the effectiveness of prosthodontic rehabilitation in patients with PD.

## MATERIALS AND METHODS

The PROSPERO database has the study protocol registered under Registration ID CRD42024570296. The Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) standards were followed in the reporting of the review.<sup>[8]</sup> Figure 1 shows the flowchart created using the PRISMA guidelines.

## REVIEW QUESTION AND CRITERIA

The study was conducted a systematic review utilizing the population, intervention, comparison, and outcomes (PICO) framework to answer the question "What is the effectiveness of prosthodontic rehabilitation in patients with PD?" PICO framework was used for studies, where intervention was done in PD patient and comparison was done with patients with or without Parkinson but without intervention.

P: Patients with PD.

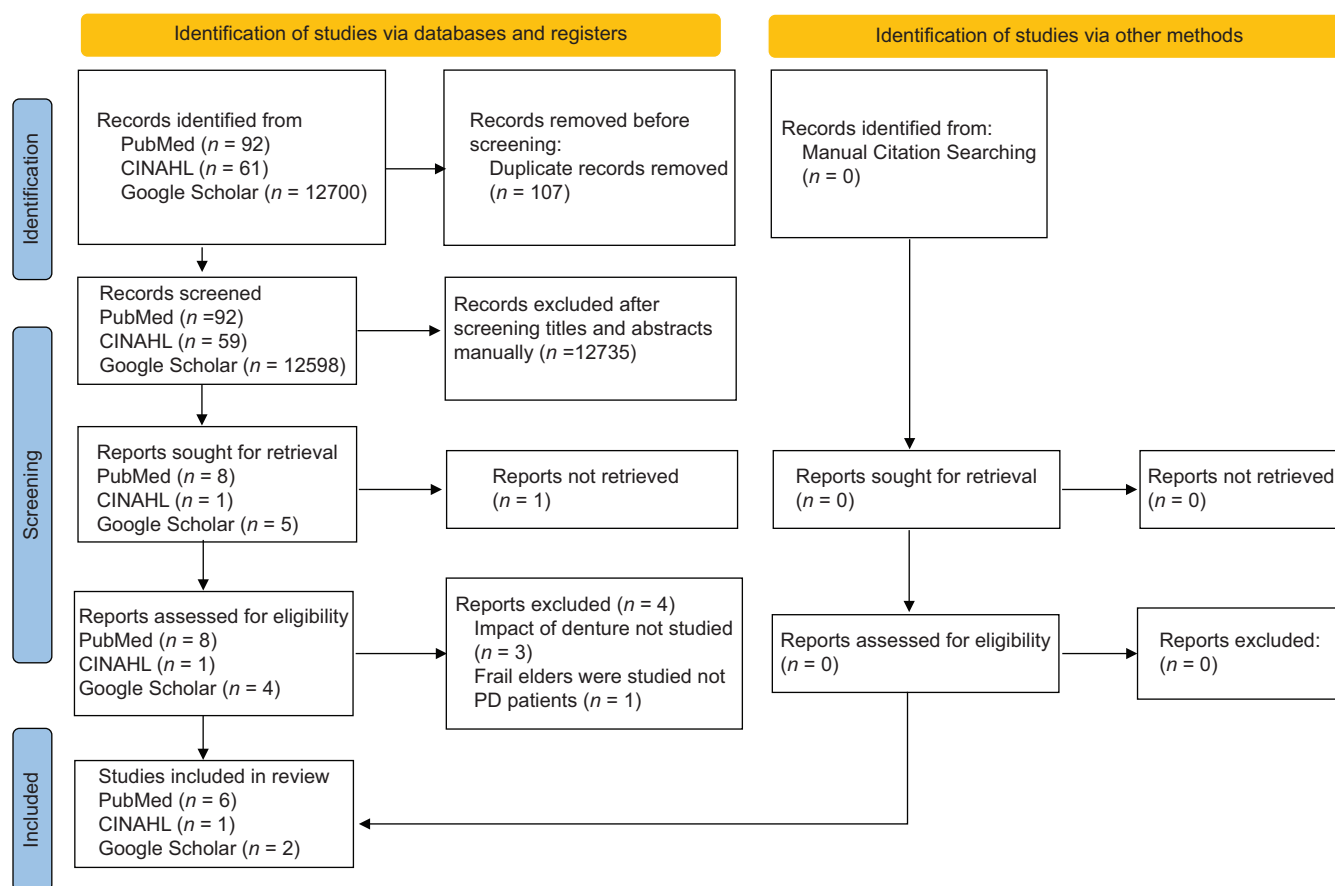
I: Rehabilitation with either fixed or RP.

C: Patients without prosthodontic rehabilitation with or without PD.

O: Effectiveness of prosthodontic rehabilitation on various oral aspects and QoL.

## LITERATURE SEARCH STRATEGY

The literature search was conducted in the PubMed and CINAHL database to identify pertinent articles using the following search items ("Parkinson disease" OR "Parkinson's disease" OR "Parkinsonism") AND ("Dental prosthesis" OR "Removable prosthesis" OR "Denture" OR "dentures" OR "Complete denture" OR "Denture, complete" OR "Removable partial denture" OR "Denture partial removable" OR "Dental implants" OR "Oral rehabilitation" OR "Overdenture" OR "denture, overlay" OR "fixed prosthesis" OR "Crown" OR "Fixed partial denture"). The search strategy used for various databases is depicted in Table 1. The search was done for the articles from



**Figure 1:** Article selection strategy based on Preferred Reporting Items for Systematic Reviews and Meta-analyses guideline.

the year of inception to 2024 in English language. In addition, an examination of gray literature was conducted using Google Scholar to find pertinent papers that could not be found using the given search parameters. Further search criteria (inclusion and exclusion criteria's) were applied to the articles and after reading the entire text of the articles, those that met the requirements were chosen for review. To identify any further relevant article, the bibliography of the chosen articles was manually searched as well.

### Inclusion and exclusion criteria

Inclusion and exclusion criteria are enlisted in Table 2.

### Study selection

There were two stages involved in choosing which articles to include. In the first step, suitable research was identified in the electronic databases based on the inclusion and exclusion criteria by reviewing the article titles and abstracts. Two researchers independently evaluated the full texts of the articles that were chosen following the first screening in the second stage. To come to a final consensus, any differences in the choice of the final articles were discussed between the two researchers and the third researcher.

### Risk of bias assessment

The methodological quality assessment of cohort studies was done using Newcastle–Ottawa Quality Assessment form for Cohort Studies (NOS).<sup>[9]</sup> Assessment of cross-sectional studies was done using the Appraisal tool for Cross-sectional Studies (tool).<sup>[10]</sup> A high-quality publication was one in which the total appraisal scores for the critical appraisal section of the study accounted for at least 14 out of 20 questions scoring at 1, or a score  $\geq 14$ . Fair quality was assigned to publications having score between 60% and 69% and low-quality publications had score  $< 60\%$ . Assessment of case series was done using Joanna Briggs Institute (JBI) critical appraisal tool for case series.<sup>[11]</sup> JBI score higher than 70% was classified as having a good quality, a score between 50% and 70% as having a fair quality, and a score  $< 50\%$  as having a poor quality.

### Data extraction

Data from the final selected articles were done by two authors independently in terms of authors' names, publication years and country, type of study, parameter studied, sample size, mean age of participants, and type of prosthetic intervention

and evaluation period [Table 3]. Moreover, Tables 4-7 gave comprehensive information about each parameter of oral function tested in the selected studies, i.e., masticatory efficiency, oral perception and motor ability, oral health QoL, and electromyographic (EMG) activity of masticatory muscles. Details in these tables include method of assessment of the studied parameter, results of the

parameter evaluated for study group and control group if present, author's conclusion and limitations of the study.

## RESULTS

Using the search parameters, a total of 92 abstracts appeared in PubMed. Based on inclusion and exclusion criteria, eight articles were selected for full-text reading. Out of eight articles, two were rejected as one studied the effect of PD on RP hygiene and not the effectiveness of prosthesis and the other included PD patients with and without dentures and studied the oral health but not the consequence of denture wear. From the CINAHL database, after removing the duplicates, only one article was found to be suitable for inclusion in the review. Five articles were selected from Google Scholar for full-text reading. One was excluded as the full text was not available and another was rejected as chewing ability and oral Health-related QoL (OHRQoL) was studied in frail elders with and without prosthesis but not

**Table 1: Inclusion and exclusion criteria**

Inclusion criteria	Exclusion criteria
Articles written in English language	Articles written in languages other than English
Original research, <i>in-vivo</i> studies	Case reports, letters to editor, review papers, systematic reviews, meta analysis, commentaries, animal studies
Studies including PD patients with prosthodontic rehabilitation (fixed or removable)	Studies discussing the oral health conditions of patient's with PD without any prosthodontic rehabilitation
Studies including PD patients with and without dentures	Studies discussing impact of prosthodontic intervention in patients with neurological disabilities other than PD

PD: Parkinson disease

**Table 2: Search terms and strategy for the electronic databases**

Database	Search number	Combination of search terms and strategy	Number of titles
PubMed	#1	("Parkinson disease" [Mesh Terms] OR "Parkinson's disease" OR "Parkinsonism")	144,745
	#2	("Dental prosthesis" [Mesh Terms] OR "Removable prosthesis" OR "Denture" OR "dentures" [Mesh Terms] OR "Complete denture" OR "Denture, complete" [Mesh Terms] OR "Removable partial denture" OR "Denture partial removable" [Mesh Terms] OR "Dental implants" [Mesh Terms] OR "Oral rehabilitation" OR "Overdenture" OR "denture, overlay" [Mesh Terms] OR "fixed prosthesis" OR "Crowns" [Mesh Terms] OR "Fixed partial denture")	114,765
	#1 AND #2	("Parkinson disease" [Mesh Terms] OR "Parkinson's disease" OR "Parkinsonism") AND ("Dental prosthesis" [Mesh Terms] OR "Removable prosthesis" OR "Denture" OR "dentures" [Mesh Terms] OR "Complete denture" OR "Denture, complete" [Mesh Terms] OR "Removable partial denture" OR "Denture partial removable" [Mesh Terms] OR "Dental implants" [Mesh Terms] OR "Oral rehabilitation" OR "Overdenture" OR "denture, overlay" [Mesh Terms] OR "fixed prosthesis" OR "Crowns" OR "Fixed partial denture" OR "Denture, partial, fixed" [Mesh Terms])	92
CINAHL	#1	("Parkinson disease" OR "Parkinson's disease" OR "Parkinsonism")	5000
	#2	("Dental prosthesis" OR "Removable prosthesis" OR "Denture" OR "dentures" OR "Complete denture" OR "Denture, complete" OR "Removable partial denture" OR "Denture partial removable" OR "Dental implants" OR "Oral rehabilitation" OR "Overdenture" OR "denture, overlay" OR "fixed prosthesis" OR "Crown" OR "Fixed partial denture")	5000
	#1 AND #2	("Parkinson disease" OR "Parkinson's disease" OR "Parkinsonism") AND ("Dental prosthesis" OR "Removable prosthesis" OR "Denture" OR "dentures" OR "Complete denture" OR "Denture, complete" OR "Removable partial denture" OR "Denture partial removable" OR "Dental implants" OR "Oral rehabilitation" OR "Overdenture" OR "denture, overlay" OR "fixed prosthesis" OR "Crown" OR "Fixed partial denture")	61
Google Scholar	#1	("Parkinson disease" OR "Parkinson's disease" OR "Parkinsonism")	17,600
	#2	("Dental prosthesis" OR "Removable prosthesis" OR "Denture" OR "dentures" OR "Complete denture" OR "Denture, complete" OR "Removable partial denture" OR "Denture partial removable" OR "Dental implants" OR "Oral rehabilitation" OR "Overdenture" OR "denture, overlay" OR "fixed prosthesis" OR "Crown" OR "Fixed partial denture")	497,000
	#1 AND #2	("Parkinson disease" OR "Parkinson's disease" OR "Parkinsonism") AND ("Dental prosthesis" OR "Removable prosthesis" OR "Denture" OR "dentures" OR "Complete denture" OR "Denture, complete" OR "Removable partial denture" OR "Denture partial removable" OR "Dental implants" OR "Oral rehabilitation" OR "Overdenture" OR "denture, overlay" OR "fixed prosthesis" OR "Crown" OR "Fixed partial denture")	12,700

**Table 3: Characteristics of included study from PubMed, CINAHL, and Google Scholar**

Database	Author, year, country	Type of study	Outcome studied	Number of participants	Mean age of participants	Intervention/prosthetic status	Evaluation period
PubMed	Ribeiro <i>et al.</i> , 2017 <sup>[12]</sup> Brazil	Observational clinical study	OHRQoL and mastication	Group with PD: 17 (9 men and 8 women) Control group: 17 (10 men and 7 women)	Group with PD: 69.4±4.7 years Control group: 70.7±4.7 years	Removable prosthesis (complete denture and RPD)	At baseline and after 2 months
PubMed	Ribeiro <i>et al.</i> , 2017 <sup>[13]</sup> Brazil	Clinical trial	Masticatory function including range of jaw motion, chewing movements, masticatory performance, and maximum bite force	Group with PD: 17 (9 men and 8 women) Control group: 17 (10 men and 7 women)	Group with PD: 69.41±4.65 years Control group: 70.71±4.65 years	Removable prosthesis (complete denture and RPD)	After 2 months
PubMed	Packer <i>et al.</i> , 2009 <sup>[14]</sup> UK	Comparative study	OH-QoL	9 men (After 12 months, 1 patient died, thus 8 men completed the study)	63 years	Implant supported overdenture or implant supported fixed prosthesis	At baseline, after 3 months and after 12 months
PubMed	Leung <i>et al.</i> , 2002 <sup>[15]</sup> Hong Kong	Cross-sectional study	Oral perception and oral motor ability	Group with PD: 15 (7 men and 8 women) Control group: 15 (11 men and 4 women)	Group with PD: 71 years Control group: 69 years	Group with PD: 12 wore dentures out of 15 Control group: All 15 participants wore dentures	Evaluation done without dentures and with dentures
PubMed	Pow <i>et al.</i> , 2001 <sup>[16]</sup> , Hong Kong	Cross-sectional study	Oral stereognosis	Group with PD: 35 (15 men and 20 women) Control group: 35 (10 men and 25 women) In each group, there were 20 partially dentate and 15 edentulous patients	Group with PD: 63.9 in partially dentate patients and 71.4 in edentulous patients Control group: 59.0 in partially dentate patients and 68.8 in edentulous patients	Group with PD: 12 wore dentures out of 15 edentulous patients Control group: All 15 participants wore dentures	Evaluation done without dentures and with dentures
PubMed	Heckmann <i>et al.</i> , 2000 <sup>[17]</sup> Germany	Pilot study	Chewing and predigestion capacity	3 edentulous patients (2 men and 1 women)	75.66 years	Implant-supported overdenture	At baseline and after 42, 35 and 28 months respectively
CINAHL	Oliveira <i>et al.</i> , 2023 <sup>[18]</sup> Brazil	Cross-sectional study	EMG activity of masticatory muscles	41 (26 men and 15 women) Denture wearing: 28 Nondenture wearing: 13	64±9 years	Removable prosthesis (complete denture and RPD)	Did not mention follow-up
Google Scholar	Darwish, 2022 <sup>[19]</sup> Egypt	Cross-over study	Patient satisfaction	10 (6 males and 4 females)	54 years	RPD (hard acrylic and flexible)	1 month for acrylic RPD and 1 month for flexible RPD
Google Scholar	Massimo <i>et al.</i> , 2020 <sup>[20]</sup> Italy	Retrospective observational study	Orofacial functions and chewing efficiency	Group with PD: 24 (15 men and 9 women) Control group: 24 (14 men and 10 women)	Group with PD: 71.4±5.9 years Control group: 71±4.1 years	Removable prosthesis (complete denture and RPD)	Did not mention follow-up. Both study group and control group already had prosthesis at the time of admission to the study

PD: Parkinson disease; RPD: Removable partial denture; OHRQoL: Oral health-related quality of life; OH-QoL: Oral Health Quality of Life; EMG: Electromyographic

specifically the PD patients. One more article was rejected as it studied the masticatory function and oral sensorimotor ability in PD patients and included

denture wearers and nondenture wearers but did not study the impact of dentures on these functions. Thus, 9 articles were included in this systematic review.<sup>[12-20]</sup>

**Table 4: Results of included study for masticatory efficiency**

Author	Method of assessment	ME of PD group	ME of control group	Conclusion	Limitations
Ribeiro <i>et al.</i> <sup>[12]</sup>	Optocal artificial test material	At baseline: 7.0±9.8 After prosthesis insertion: 13.9±13.2	At baseline: 13.0±11.3 After prosthesis insertion: 23.9±17.2	After insertion of the removable prostheses, ME increased in the group with PD. However, ME in elders with PD remained below control levels	Did not study the quality of residual alveolar ridge that could influence masticatory efficiency. General dental treatment that can influence OHRQoL result due to its positive impact on oral perception was not included
Ribeiro <i>et al.</i> <sup>[13]</sup>	Range of jaw movements: Jaw-tracking kinesiograph device Chewing movements: Optocal artificial test material Masticatory performance: sieving procedure Maximum bite force: Bite force transducer	Range of jaw movements Frontal: 21.86–2.75 Sagittal: 18.94 Horizontal: 7.53–4.22 Longer cycle times for opening, closing, occlusal phase, and total mastication, and slower opening and closing velocities during Optocal mastication ( $P<0.05$ ) Masticatory performance: 5.69 Maximum bite force: 89.80	Range of jaw movements Frontal: 34.79–6.73 Sagittal: 31.71 Horizontal: 11.44–12.5 Shorter cycle times for opening, closing, occlusal phase, and total mastication, and slower opening and closing velocities during Optocal mastication Masticatory performance: 4.24 Maximum bite force: 157.90	PD reduced the amplitude of the jaw motion range, masticatory cycle durations, chewing velocity, masticatory performance, and maximal bite force, among other masticatory function measures	Data regarding PD stage, which influences motor symptoms and the severity of the disease, was not gathered. Additionally, the assessment was carried out when levodopa was “on,” which is when PD patient’s motor performance was at its best
Heckmann <i>et al.</i> <sup>[17]</sup>	Chewing and predigestion capacity: Body weight GI symptoms using questionnaire that includes abdominal bloating, heartburn, dysphagia, regurgitation and constipation	At baseline Body weight (kg): 71, 53, 82 After prosthesis insertion: 72.5, 55, 85 Percent (%) improvement in GI score: 17, 75, 40 respectively	No control group included	Implant supported prosthesis resulted in moderate gain of body weight and improved GI score thus, improving chewing capacity and oropharyngeal predigestion	Not mentioned
Massimo <i>et al.</i> <sup>[20]</sup>	Orofacial dysfunction: NOT-S Masticatory ability: Subjective evaluation index of masticatory ability ME using two-colour chewing gum test	Orofacial dysfunction (NOT-S): 4.5±2.3 Masticatory ability: 1.08±0.99 ME: 3.2±0.39	Orofacial dysfunction (NOT-S): 1.08±1.08 Masticatory ability: 0.83±0.83 ME: 3.5±0.8	Statistically significant difference in the outcomes of the oro-facial dysfunctions ( $P=0.001$ ) Nonsignificant difference observed for masticatory ability and efficiency Statistically significant correlation between the temporal duration of use of a prosthetic device and the degree of masticatory efficiency ( $P<0.05$ )	Small sample size

ME: Masticatory efficiency; PD: Parkinson disease; NOT-S: Nordic Orofacial Test-Screening; GI: Gastro-intestinal; OHRQoL: Oral health-related quality of life

Risk of bias assessment done using various tools depicted seven out of nine selected articles of high quality and two or fair quality [Tables 8-10].

### Study characteristics

Four articles studied the masticatory efficiency.<sup>[12,13,17,20]</sup> Out of these four articles, comparative study between PD and non-PD group was done in three articles<sup>[12,13,20]</sup> and the fourth article included all patients with PD.<sup>[17]</sup>

Oral perception and motor ability were analyzed in two articles.<sup>[15,16]</sup> OHQoL was assessed in four articles.<sup>[12,14,17,19]</sup> One article studied the EMG activity of the masseter and temporalis muscle.<sup>[18]</sup>

### Result of studies for masticatory efficiency<sup>[12,13,17,20]</sup>

Out of four studies, one study evaluated only the chewing efficiency and found improvement in the ME after usage of RP. However, significant

**Table 5: Results of included study for oral perception and motor ability**

Author	Method of assessment	ME of PD group	ME of control group	Conclusion	Limitations
Leung <i>et al.</i> <sup>[15]</sup>	Oral perception: Stereognostic tests using solid objects of different shapes Oral motor ability test: Using two part test pieces with different shapes	Average response time in Stereognostic test: Without denture: 16.6 With denture: 10.7 Average OMA time: Without denture: 102.2 With denture: 87.0	Average response time in Stereognostic test: Without denture: 11.1 With denture: 7.8 Average OMA time: Without denture: 57.6 With denture: 48.7	The degree of the differences in OMA and stereognostic scores across the groups with and without dentures did not seem to differ	Not mentioned
Pow <i>et al.</i> <sup>[16]</sup>	Stereognostic test using solid objects of different shapes	Average response time in stereognostic test: Without denture: 16.6 in edentulous With denture: 10.7 in edentulous	Average response time in stereognostic test: Without denture: 11.1 in edentulous With denture: 7.8 in edentulous	The stereognostic ability of edentulous PD patients and the control group were similar, with or without dentures	Not mentioned

ME: Masticatory efficiency; PD: Parkinson disease; OMA: Oral motor ability

**Table 6: Results of included study for oral health quality of life**

Author	Method of assessment	Result of PD group	Result of control group	Conclusion	Limitations
Ribeiro <i>et al.</i> <sup>[12]</sup>	OHIP-49 13 questionnaire	At baseline: 76.4±5.6 After prosthesis insertion: 18.2±13.3	At baseline: 38.7±19.6 After prosthesis insertion: 10.7±8.2	The OHIP-49 total scores declined in comparison to baseline after removable prosthesis were inserted in PD patients. The majority of the domains experienced declines, indicating that those domains had a favorable effect on OHRQoL	Did not study the quality of residual alveolar ridge that could influence ME General dental treatment that can influence OHRQoL result due to its positive impact on oral perception was not included
Packer <i>et al.</i> <sup>[14]</sup>	OH-QoL inventory, and SROH	Significant difference between pretreatment and 3-month and the pretreatment and 12-month means ( $P<0.001$ ), but no significant difference between the 3- and the 12-month means ( $P=0.6$ )	No control group was included in the study	The use of dental implants to support a fixed prosthesis or stabilize an overdenture enhanced the QoL for PD patients in the areas of eating, oral health, and prosthesis satisfaction	Not mentioned
Heckmann <i>et al.</i> <sup>[17]</sup>	A self-rating scale Questionnaire to assess satisfaction with implant-supported prosthesis	Each patient rated their ability to chew using a self-rating scale as "much better" than the previous denture	No control group was included in the study	Implant-supported overdentures offer a treatment option for edentulous PD patients that may significantly improve their condition subjectively	Not mentioned
Darwish <sup>[19]</sup>	Questionnaire where rating was done for appearance, ease of cleaning, ability to speak, ability to insert and remove the RPD, and comfort while eating and talking	Significant difference between all parameters for satisfaction ( $P<0.05$ ) except for cleanliness, where there was a nonsignificant difference	No control group	More than 70% of participating patients were totally satisfied with flexible partial dentures than conventional hard acrylic partial dentures	Limited sample size Short follow-up period

OHIP-49: Oral Health Impact Profile-49; ME: Masticatory efficiency; PD: Parkinson disease; SROH: Self-reported assessment of oral health and functional status; OHRQoL: Oral health-related quality of life; OH-QoL: Oral Health Quality of Life, RPD: Removable partial denture

difference was found in ME of patients with PD and without PD.<sup>[12]</sup> Second study observed decrease in ME as assessed by jaw motion range, masticatory cycle durations, chewing velocity, masticatory performance, and maximal bite force.<sup>[13]</sup> Third study evaluated gastro-intestinal symptoms and found improved GI scores after prosthesis insertion, thus

improving chewing capacity and oropharyngeal predigestion.<sup>[17]</sup> Fourth study evaluated orofacial dysfunction, masticatory ability and masticatory efficiency and observed statistically significant difference in the outcome of orofacial dysfunctions but nonsignificant difference for masticatory ability and efficiency.<sup>[20]</sup>

**Table 7: Results of included study for electromyographic activity by assessing average maximum voluntary contractions**

Author	Method of assessment	ME of PD group (denture wearers)	ME of control group (nondenture wearers)	Conclusion	Limitations
Oliveira <i>et al.</i> <sup>[18]</sup>	Miotool Face 200/400 electromyograph	MVC Masseter Upper RPD: 227 U/L RPD: 148 Upper full denture and lower RPD: 119 Temporalis Upper RPD: 221 U/L RPD: 171 Upper full denture and lower RPD: 127	MVC Masseter: 245 Temporalis: 252	Denture wearing negatively influenced the electrical activity of masticatory muscles in individuals with PD	Electrical activity was not assessed before prosthesis insertion thus pre and postprosthesis insertion EMG activity could not be assessed Its usage of a secondary database and a nonprobabilistic convenience sample impedes sample computation Small sample size

MVC: Maximum voluntary contractions; RPD: Removable partial denture; ME: Masticatory efficiency; PD: Parkinson disease; EMG: Electromyographic

**Table 8: The methodological quality assessment cohort studies, with Newcastle-Ottawa quality assessment form for cohort studies (Newcastle–Ottawa Scale)**

Article	Ribeiro <i>et al.</i> <sup>[12]</sup>	Ribeiro <i>et al.</i> <sup>[13]</sup>	Packer <i>et al.</i> <sup>[14]</sup>	Darwish <sup>[19]</sup>	Massimo <i>et al.</i> <sup>[20]</sup>
Representativeness of the exposed cohort	b (1)	b (1)	b (1)	b (1)	b (1)
Selection of the nonexposed cohort	a (1)	a (1)	a (1)	c	a (1)
Ascertainment of exposure	a (1)	a (1)	a (1)	a (1)	b (1)
The desired outcome was not present at start of study	b	b	b	b	b
Comparability of cohorts on the basis of the design or analysis	a (1)	a (1)	a (1)	a (1)	a (1)
Comparability of the additional factor	b	b	b	b	a (1)
Assessment of outcome	b (1)	b (1)	b (1)	b (1)	a (1)
Was follow-up long enough for outcomes to occur	b	b	a (1)	b	a (1)
Adequacy of follow up of cohorts	a (1)	a (1)	b	a (1)	a (1)
Quality	Good	Good	Good	Fair	Good

Parenthesis indicates number of stars. NOS: Newcastle–Ottawa Scale; Good quality: 3 or 4 stars in selection domain AND 1 or 2 stars in comparability domain AND 2 or 3 stars in outcome domain; Fair quality: 2 stars in selection domain AND 1 or 2 stars in comparability domain AND 2 or 3 stars in outcome domain

### Result of studies for oral perception and motor ability<sup>[15,16]</sup>

Based on the result of the two studies included in the review, oral perception and motor ability did not reveal any significant difference in outcome with or without dentures.

### Result of studies for quality of life<sup>[12,14,17,19]</sup>

OHQoL of PD patients improved after prosthesis usage. RPD using flexible material was found to be better than the hard acrylic material.<sup>[19]</sup> Implant supported overdenture or fixed prosthesis offer a viable treatment option significantly improving the QoL of PD patients.<sup>[14,17]</sup>

### Result of studies for electromyographic activity<sup>[18]</sup>

Based on one study, wearing of RP whether complete denture or RPD negatively influenced the electrical activity of masticatory muscles in individuals with PD when compared with individuals who do not wear dentures. There were no differences observed for the right and left sides. The masseter muscle analysis showed statistically significant

differences ( $P = 0.0018$ ) between those with different types of dentures and those without dentures. There were statistically significant differences ( $P = 0.0034$ ) in the anterior temporalis muscle between the nondenture and denture wearing group. However, the electrical activity was not assessed at baseline, i.e., before the prosthesis insertion, and hence, whether the prosthesis had an impact on electrical activity of the muscles could not be directly assessed.

## DISCUSSION

Patients suffering from PD could experience difficulties during swallowing or speaking. These can occur at any moment, but as PD worsens, they often get worse. The muscles in the face, mouth, and throat used for speaking and swallowing are also impacted by PD in a similar way to how it affects movement in other body regions. This results in oral dysfunction. PD patients may experience difficulties in maintaining oral hygiene resulting in compromised dental health.



**Table 9: The methodological quality assessment of cross-sectional studies, using the appraisal tool for cross-sectional studies (AXIS tool)**

Article	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	AXIS score/20
Leung <i>et al.</i> <sup>[15]</sup>	Yes	Yes	Yes	Yes	Yes	Yes	?	Yes	Yes	Yes	Yes	Yes	No	N/A	Yes	Yes	Yes	No	No	?	14 high quality
Pow <i>et al.</i> <sup>[16]</sup>	Yes	Yes	Yes	Yes	Yes	Yes	?	Yes	Yes	Yes	Yes	Yes	No	N/A	Yes	Yes	Yes	No	No	?	14 high quality
Oliveira <i>et al.</i> <sup>[18]</sup>	Yes	Yes	Yes	Yes	Yes	Yes	?	Yes	Yes	Yes	Yes	Yes	No	N/A	Yes	Yes	Yes	Yes	No	Yes	16 high quality

Q: Question; ?: Not clear; N/A: Not applicable; Q1: Where the aims/objectives of the study clear?; Q2: Was the study design appropriate for the stated aim(s); Q3: Was the sample size justified?; Q4: Was the target/reference population clearly defined? (is it clear who the research was about?); Q5: Was the sample frame taken from an appropriate population base so that it closely represented the target/reference population under investigation?; Q6: Was the selection process likely to select subjects/participants that were representative of the target/reference population under investigation?; Q7: Were measures undertaken to address and categorize nonresponders?; Q8: Were the risk factor and outcome variables measured appropriate to the aims of the study?; Q9: Were the risk factor and outcome variables measured correctly using instruments/measurements that had been trialed, piloted or published previously?; Q10: Is it clear what was used to determine statistical significance and/or precision estimates? (e.g., *P* values, CIs); Q11: Were the methods (including statistical methods) sufficiently described to enable them to be repeated?; Q12: Were the basic data adequately described?; Q13: Does the response rate raise concerns about nonresponders bias?; Q14: If appropriate, was information about nonresponders described?; Q15: Were the results internally consistent?; Q16: Were the results presented for all the analyses described in the methods?; Q17: Were the author's discussions and conclusions justified by the results?; Q18: Were the limitations of the study discussed?; Q19: Were there any funding sources or conflicts of interest that may affect the author's interpretation of the results?; Q20: Was ethical approval or consent of participants attained?; CIs: Confidence intervals

**Table 10: The methodological quality assessment of case series: Joanna Briggs Institute critical appraisal tool**

Article	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Quality
Heckmann <i>et al.</i> <sup>[14]</sup>	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	No	Fair

Q1: Were there clear criteria for inclusion in the case series?; Q2: Was the condition measured in a standard, reliable way for all participants included in the case series?; Q3: Were valid methods used for identification of the condition for all participants included in the case series?; Q4: Did the case series have consecutive inclusion of participants?; Q5: Did the case series have complete inclusion of participants?; Q6: Was there clear reporting of the demographics of the participants in the study?; Q7: Was there clear reporting of clinical information of the participants?; Q8: Were the outcomes or follow up results of cases clearly reported?; Q9: Was there clear reporting of the presenting site(s)/clinic(s) demographic information?; Q10: Was statistical analysis appropriate?

Malnutrition can be spurred on by poor dental health, which can also impair appetite and digestion, compromising overall health and well-being. Impaired motor functions in PD affects the masticatory muscles which further affects the masticatory efficiency, oral perception, and oral motor ability and thus QoL of PD patients.

Assessment of chewing movement in patients with PD have shown that PD causes motor dysfunction causing alteration in chewing speed resulting in decline of the nutritional status.<sup>[21]</sup> Maximal biting force and other chewing functions, including chewing speed, have been observed to decline with PD. Patients with PD experience decreased jaw mobility, as well as jaw tremor and stiffness in the masticatory and face muscles. They have rigidity and slowness in their orofacial muscles, as well as involuntary facial movements and reduced tongue movements that lead to orofacial pain, temporomandibular joint symptoms as well as difficulties with chewing, speech, and jaw mobility.<sup>[22]</sup> PD patients exhibit postural deviations that might cause physical imbalance by shifting the head's posture, which in turn shifts the mandibular position.<sup>[23]</sup> Muscular compensation and a reduction in masticatory efficiency may result from this modification to the masticatory pattern.<sup>[24]</sup>

Stereognosis is a complex sensory phenomenon and a vital function depicting oral perception of various objects without visual or auditory information. Any alteration in oral stereognosis have negative implications on mastication and swallowing.<sup>[25]</sup> Studies have shown that oral stereognostic ability is impaired in edentulous patients than in dentate patients and the oral stereognostic level of totally edentulous patients (without denture) is higher than complete denture wearer.<sup>[26]</sup> According to the results of a systematic analysis of the impact of CD on OSA in edentulous patients, rehabilitation using a full denture improves stereognostic ability in terms of accurately identifying test pieces and the amount of time needed to do so. In addition, a clear correlation between stereognostic ability and denture adaptation was observed.<sup>[27]</sup> In relation to the type of prosthesis, study done to investigate OSA of dentate patients, CD wearers, and maxillary implant supported dentures did not found any statistically significant difference between conventional denture wearers and implant supported dentures wearers.<sup>[28]</sup>

The OHRQoL is a subjective phenomenon and is crucial to clinical practice in determining the patient's needs. OHRQoL could be affected by PD.<sup>[3,29]</sup> In addition, PD patients with oral symptoms have lower OHRQoL than PD patients without oral symptoms.<sup>[30]</sup>

OHRQoL can be measured with several instruments. Compared to patients without PD, patients with PD have lower OHRQoL.<sup>[31]</sup> PD patients may exhibit orofacial pain<sup>[32]</sup> and this can significantly influence vital human needs such as eating and chewing, which can have a negative impact on the QoL.<sup>[33]</sup> Studies included in this review suggest that prosthetic rehabilitation can have a positive impact on the QoL of PD patients. Although improved scores has been observed using RP, however, implant-supported fixed or RP offer more reliable rehabilitation option in PD patients. According to a systematic review on oral health and implant therapy in PD patients, PD patients have issues using mobile prostheses due to a lack of motor control, and muscle rigidity that make retention of the RP difficult. Implant therapy although have a lower survival rate in PD patients, however, considering the convenience it offers, implant therapy must be considered a treatment of choice for increasing the QoL of PD patients.<sup>[34]</sup> Moreover, there is also evidence that despite motor impairments relating to movement and daily living activities and poor dental health, PD patients have a pleasant perspective of life assessed using Parkinson's disease questionnaire-39.<sup>[35]</sup>

EMG activity of the masticatory muscles decreases after tooth loss. In patients with PD, tooth loss is more evidently seen due to poor oral health. Evidence suggests that PD interferes with the EMG activity of the masticatory cycles by reducing muscular efficiency.<sup>[2]</sup> The result of the study included in this review suggests that EMG activity is more in dentate individuals than partially dentate or completely edentulous patients with or without PD. This decrease in masticatory muscle electrical activity could be attributed to muscle atrophy, which is increased in PD patients due to motor symptoms that impair the masticatory function.<sup>[18]</sup> People who have PD use more muscle fibers during masticatory movements than people who do not have the disease. This result in an increase in energy expenditure and indicate that PD patients had impaired functioning.<sup>[16]</sup> According to a prior study comparing patients' elevator muscle activity before and after receiving complete dentures, using complete dentures increases the occlusal vertical dimension, which in turn causes EMG alterations.<sup>[36]</sup> Another research suggests that there is alteration in the EMG characteristics of the jaw muscles in patients receiving dental prosthesis rehabilitation. EMG activity assessment between nondenture wearers and those rehabilitated with fixed

implant-supported (FIS) prosthesis and RP exhibited notable differences with the RP group exhibiting more variations than the ND participants suggesting that rehabilitation through FIS would better retain the physiology of the jaw muscles than RP.<sup>[37]</sup>

Based on the limited research, it seems that oral rehabilitation of completely or partially edentulous PD patients result in improved oral functions. Strengths of this systematic review include the thorough electronic search in two databases, one supplementary database as well as manual search with comprehensive evaluation and quality assessment of the selected articles of different study designs. The limitation is this review is the scarcity of data, and language restriction. Search in more databases with inclusion of non-English publications could be done in further reviews.

## CONCLUSION

This comprehensive evaluation suggests that prosthetic rehabilitation may be beneficial for persons with PD. Nevertheless, there is a paucity of long-term studies assessing the benefits of prosthetic rehabilitation whether with a fixed or RP in enhancing patients' QoL and oral function. Various case reports or oral rehabilitation in these patients have been reported in the literature, however, long-term follow-up to study the influence on oral functional capacity is lacking. Hence, any evidence based conclusive finding cannot be withdrawn.

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## Conflicts of interest

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