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Original articles

Removable dentures and electrical activity of masticatory muscles in individuals with Parkinson's disease

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ABSTRACT

Purpose: to assess the influence of dentures on the electromyographic activity of masticatory muscles in individuals with Parkinson's disease.

Methods: an analytical, quantitative, cross-sectional study conducted at a public teaching hospital in 2017, assessing the stage of the disease, non-denture (ND) wearing, upper removable partial denture wearing (DW1), upper and lower removable partial denture wearing (DW2), and upper complete denture + lower removable partial denture wearing (DW3). The Student-Newman-Keuls test was used to compare the maximum voluntary muscle contraction between sides and between the denture wearing and non-denture wearing groups. Significance was set at $\alpha<0.05$.

Results: after applying the eligibility criteria, 41 patient records were included in the sample. The association between the stage of the disease and denture wearing showed predominance of DW2 in stage 1 (43%). A significant difference was found in the masseter muscle analysis between the non-denture wearing group and DW2 and DW3 ($p=0.0018$). As for the anterior temporalis muscle, there was a significant difference ($p=0.0034$) in three of the analysis groups (ND *vs*. DW2, ND *vs*. DW3, and DW1 *vs*. DW3).

Conclusion: denture wearing has a negative impact on the electrical activity of masticatory muscles when compared with individuals who do not wear dentures and have natural teeth.

Keywords: Parkinson Disease; Electromyography; Aged; Mastication; Dental Prosthesis

INTRODUCTION

Parkinson's disease (PD) is a neurodegenerative disease with progressive loss of dopaminergic neurons, leading to movement disorders. The most frequent motor symptoms of this disease include resting tremors, bradykinesia, muscle stiffness, and postural instability[1,2]. Tremors cause involuntary mandibular movements and swallowing difficulty due to motor deficits in the pharynx, compromising masticatory function, which relies on a complex integrated system consisting of muscles, ligaments, bone structures, and teeth[3]. As a result of involuntary movements and non-motor symptoms such as anxiety and depression, individuals with PD may have difficulty performing oral hygiene, eventually leading to tooth loss and compromised gingival health[4-6].

In cases of tooth loss, partial or full dentures are the most common type of rehabilitation, as they are more practical and affordable[7]. Appropriate dentures should be stable on the alveolar ridge and have good retention[3]. Otherwise, patients will not improve their speech, chewing, and swallowing functions, which are crucial for individuals with PD, considering that such functions tend to deteriorate with the symptoms of the disease[7,8].

Surface electromyography (sEMG) has been used to assess and improve such functions. This technique records the electrical potentials generated during voluntary and involuntary muscle contractions, indicating the time and intensity of muscle activity, as well as activity duration and cycles in each activation[9,10]. It can be used to verify the electrical activity of mastication muscles (such as the masseter and anterior temporalis ones) when biting and masticating and observe variances in the electrical activity[11].

Age and dental condition reduce masticatory muscle activity, mainly on the active chewing side[12]. However, removable denture wearing has proved to increase maximum voluntary contractions of the masseter and temporalis muscles when compared to non-denture wearers[13].

The amount of research approaching the use of dentures and their impact on masticatory muscle activity in PD patients is still scarce. Hence, this study is justified, as the signs and symptoms of this disease change the masticatory musculature, and wearing dentures may influence speech, mastication, and swallowing. Therefore, this study aimed to analyze the influence of removable dentures on the electromyographic activity of the masticatory muscles in PD patients.

METHODS

Study design, ethical aspects, and sampling

This analytical, quantitative, cross-sectional study used a database with 170 patient records and was conducted at a public teaching hospital and at the Parkinson Association of Pernambuco (ASP/PE) in 2017. The study was approved by the Research Ethics Committee of the Federal University of Pernambuco (CEP/UFPE), Brazil, process no. 4.169.980 and CAAE number 12255519.3.0000.5208.

Eligibility criteria

The inclusion criteria were as follows: 1) clinical diagnosis of idiopathic PD stages 1 to 3 according to the Hoehn and Yahr (HY) scale,[14] 2) use of antiparkinsonian drug ("on" phase), 3) presence of posterior teeth or dentures, and 4) being guided or taken care of by family members, with limited autonomy. The following exclusion criteria were applied: 1) presence of other neurological diseases associated with PD, 2) cognitive impairment, assessed by the Mini-Mental State Examination (MMSE), 3) edentulous individuals who did not wear removable dentures, and 4) history of mandibular or neurological surgery for PD management.

Cognitive function was obtained from patient records and assessed with MMSE, consisting of 11 items, with a maximum score of 30 points, which took 5 to 10 minutes to apply. The first part of the test evaluates memory and executive function (attention and concentration), and the second part assesses other cortical functions, such as language and attention. The cutoff scores depend on the subject's educational attainment: illiterate: 13 points; few years of education: 18 points; 8 or more years of education: 26 points[15].

Study variables

Dependent variable

Surface electromyography of the masseter and anterior temporalis muscles

The electrical activity of the masseter and anterior temporalis muscles was measured with Miotool Face 200/400 electromyograph (Miotec Equipamentos Biomédicos, Ltda, Porto Alegre, Brazil) with eight high-bandwidth acquisition channels to record short-latency evoked potentials (appropriate for sEMG) at the Oral-Motor Function Laboratory of the Department of Speech-Language-Hearing Therapy at UFPE. The equipment uses bipolar low-pressure surface electrodes with interchangeable metal/felt pads[16,17].

Before placing the electrodes, the facial skin was cleansed with a gauze pad soaked in 70% alcohol. Male patients were instructed to shave off their beard on the day of examination. To determine electrode position, the participants were asked to occlude their teeth at maximum intercuspation, exerting pressure in that position to determine the midline of the muscle belly and place the electrodes longitudinally on both sides of the muscle fibers[18,19]. The centers of the electrodes were kept 2 cm apart. The ground electrode was placed on the olecranon in the nondominant side. The procedure used disposable self-adhesive 3M Health Care electrodes (3M do Brasil, Ltda, São Paulo, Brazil).

Signals picked up by the electrodes were amplified 2,000 times (common-mode rejection ratio of 126 dB), filtered with a fourth order Butterworth bandpass filter, at cutoff frequencies between 20 and 500 Hz, digitized at 8 kHz (2 kHz per channel). Electromyographic recordings were made in a quiet room. Cotton rolls were used between the dental arches in the molar region for maximum voluntary contraction (MVC) in sEMG. The procedure followed the electromyographic recording protocol, which consisted in keeping the oral muscles relaxed with the mouth slightly open for 10 seconds (for examination at rest), followed by dental occlusion at maximum habitual intercuspation (MHI) for 5 seconds, repeated three times, with 10-second intervals[20].

The average root mean square (RMS) obtained for the three MHI recordings was used to normalize the electromyographic signal. It was used as a reference value (corresponding to 100% of the electrical activity, in microvolts [μV]) for the other calculations. Data were acquired and analyzed in MiotecSuite software 1.0.

Independent variables

Sociodemographic data: Age – in full years from the date of birth to the day of data collection; Sex – male or female; Educational attainment – in years of education; Marital status – single, married or living with a partner, widow(er), separated, or divorced; Income – in monthly minimum wages: 1 to 2; 2 to 3; 3 to 5; 5 to 10; 10 to 15; or 15 to 20.

PD Staging – According to HY scale, developed by Margareth Hoehn and Melvin Yahr,[14] as follows: stage 1 (mild impairment): unilateral manifestations (tremor, stiffness, and bradykinesia) and capacity to live independently; stage 2 (moderate impairment): bilateral manifestations combined with possible speech disorders, flexed posture, and abnormal gait; and stage 3 (moderate impairment): deteriorated bilateral manifestations of PD, in addition to balance disorders. In this stage, patients can live independently. Stages 4 and 5 are more severe forms of the disease, in which patients recurrently need help (stage 4) or are bedridden or wheelchair-bound (stage 5)[8].

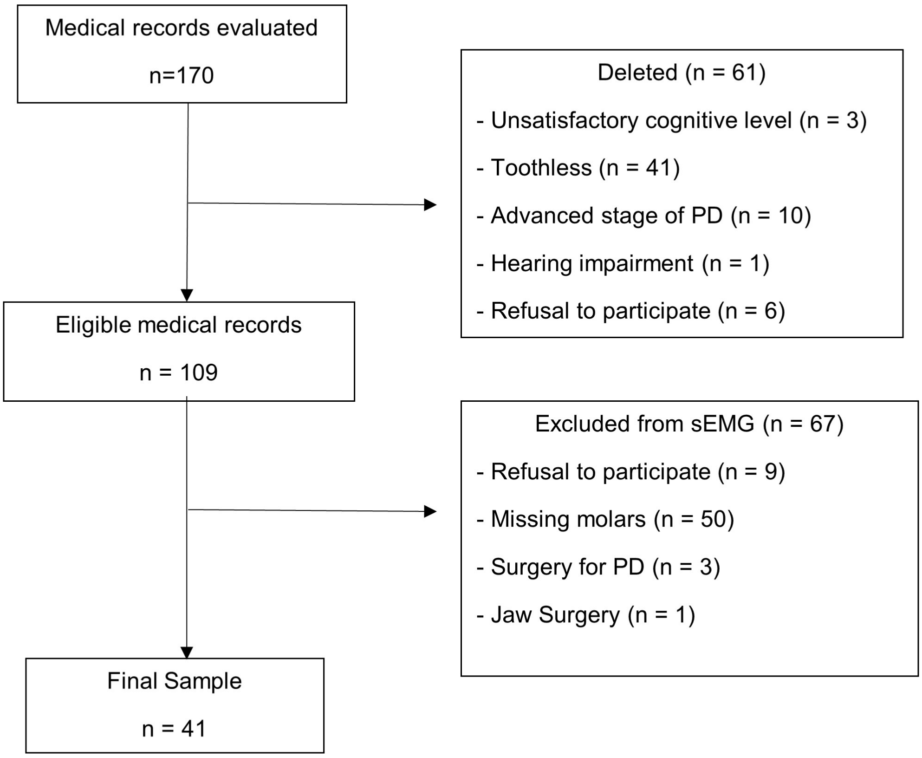
Presence or absence of removable dentures – Denture wearing was categorized as: DW1: upper removable partial dentures; DW2: upper and lower removable partial dentures; DW3: upper full dentures + lower removable partial dentures.

Statistical analysis

The data were tabulated and compiled using descriptive analysis and measures of central tendency and dispersion. Values greater than three standard deviations were excluded (outlier). The Shapiro-Wilk test was performed to assess the normality of the distribution. Non-normal distribution was observed for maximum voluntary contraction (MVC) on sEMG; therefore, nonparametric tests were employed. The Mann-Whitney test was used to compare the right and left sides of the masseter and anterior temporalis muscles, while the Kruskal-Wallis test, using the Student-Newman-Keuls as post-hoc test, was performed to compare non-denture wearers with those who wore one or more types of dentures. BioEstat 5.0 was used for the statistical analysis ($\alpha < 0.05$).

RESULTS

After analyzing 170 records of individuals with PD, 129 were excluded for not meeting the eligibility criteria. Thus, the final sample consisted of 41 patient records (Figure 1). There was predominance of male individuals (63%), mean age of 64 years, mean of 9 years of education, married individuals or individuals living with a partner (73%), income between 1 and 2 minimum wages (34%), disease in stage 2 (44%) with mean time to diagnosis of 7 years, and denture wearing (68%) (Table 1).



Captions: PD = Parkinson's disease; sEMG = Surface electromyography

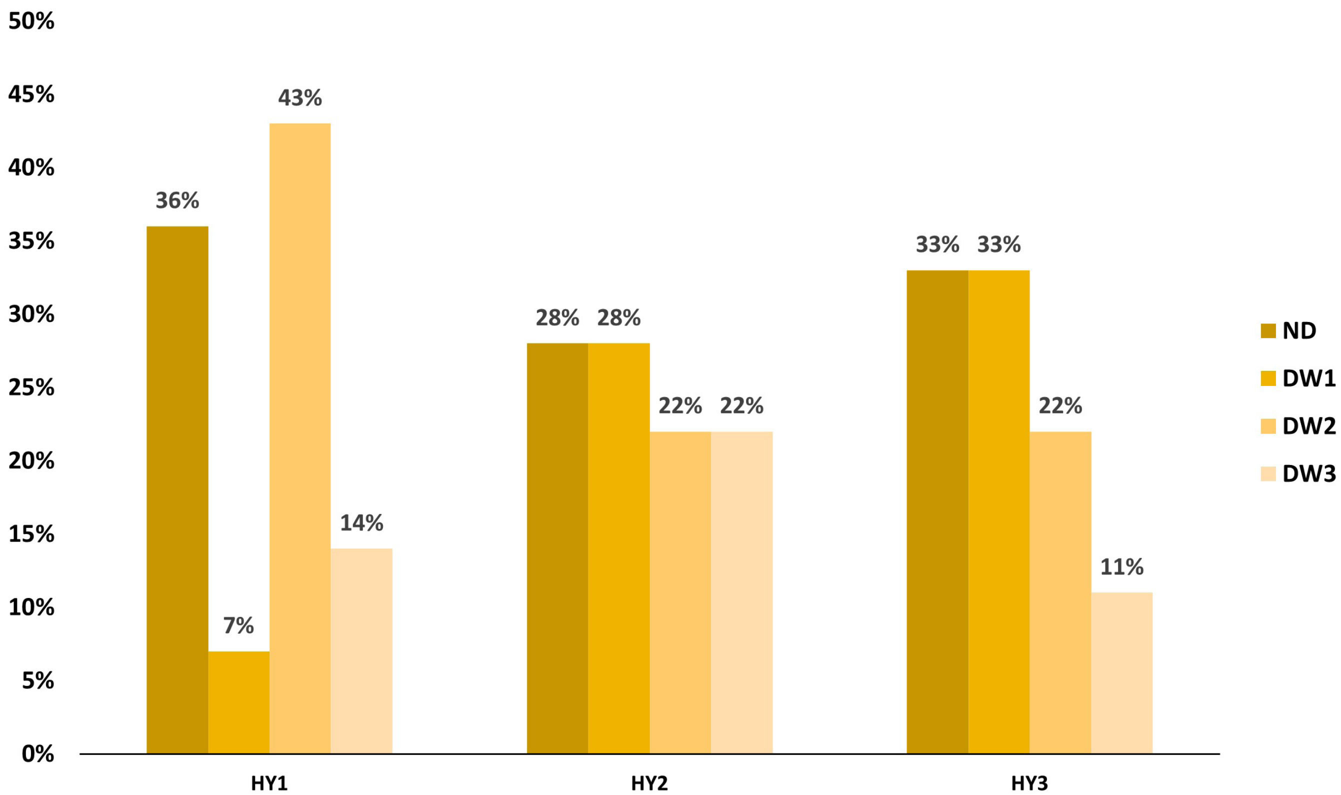
Figure 1. Flowchart showing sample selection

Table 1. Characteristics of the sample, according to sociodemographic data, stage of the disease, and denture wearing, Recife-PE, Brazil, 2023

	N	%	Mean ± standard deviation
Age (in years)			64±9
Sex			
Males	26	63%	
Females	15	37%	
Schooling (in years)			9±5
Marital status			
Married	30	73%	
Living with a partner	2	5%	
Separated	3	7%	
Widowed	4	10%	
Divorced	2	5%	
Income (MW)			
1/2 to 1	6	15%	
1 to 2	14	34%	
2 to 3	8	20%	
3 to 5	9	22%	
5 to 10	3	7%	
15 to 20	1	2%	
Stage of the disease			
1	14	34%	
2	18	44%	
3	9	22%	
Diagnosis of PD (in years)			7±4
Denture wearing			
Yes	28	68%	
No	13	32%	

Captions: N = Sample; % = Percentage; MW = number of monthly minimum wages (corresponding to the 2017 value of the minimum wage; PD: Parkinson's disease.

In the analyzed patient records, 32% did not wear dentures, whereas 22% wore upper removable partial dentures (DW1), 29% wore upper and lower removable partial dentures (DW2), and 17% wore upper full dentures + lower removable partial dentures (DW3). The types of dentures were then associated with the stages of the disease, revealing predominance of DW2 in stage 1 (43%) and DW1 in stages 2 (28%) and 3 (33%) (Figure 2).



Captions: HY: Hoehn and Yahr; ND: no denture; DW1: upper removable partial dentures; DW2: upper and lower removable partial dentures; DW3: upper full denture + lower removable partial dentures

Figure 2. Distribution of the types of dentures associated with the stages of Parkinson's disease

A total of 164 electromyographic recordings of maximum voluntary contractions (MVC) of the masseter and anterior temporalis muscles were simultaneously collected. However, no differences were observed for the right and left sides (right vs. left masseter, p=0.75; right vs. left temporalis muscle, p=0.33) (Table 2). The records were then sorted out based on muscle groups rather than on sides, considering 82 sEMG associated with the different types of dentures. The analysis of the masseter muscle, comparing non-denture wearers (ND) and those groups with different types of dentures (DW1, DW2, and DW3) revealed statistically significant differences (p=0.0018) in ND *vs*. DW2, ND *vs*. DW3, DW1 *vs*. DW2, and DW1 *vs*. DW3. Regarding the anterior temporalis muscle, there were statistical differences between the three groups analyzed (ND *vs*. DW2, ND *vs*. DW3, and DW1 *vs*. DW3) (p=0.0034) (Table 3).

Table 2. Comparison between the right and left sides of the masseter and anterior temporalis muscles regarding the average maximum voluntary contractions (MVC) and standard deviation (SD) in microvolts

	Masseter		Temporalis muscle	
	Right	Left	Right	Left
$\bar{X}$ (±)	185 (116)	194 (117)	197 (126)	207 (112)
p	0.75		0.33	

Captions: $\bar{X}$: Mean; (±): Standard deviation; Mann-Whitney test; *p<0.05

Table 3. Comparison between the average maximum voluntary contractions (MVC) of the masseter and anterior temporalis muscles and standard deviation (SD) in denture and non-denture wearers in microvolts

	ND	DW1	DW2	DW3	Kruskal-Wallis	
					p	SNK
Masseter	245 (152)	227 (111)	148 (78)	119 (47)	0.0018*	NDvsDW2 NDvsDW3 DW1vsDW2 DW1vsDW3
Temporalis	252 (134)	221 (114)	171 (83)	127 (63)	0.0034*	NDvsDW2 NDvsDW3 DW1vsDW3

Captions: ND: No denture; DW1: Upper removable partial dentures; DW2: Upper and lower removable partial dentures; DW3: Upper full dentures + lower removable partial dentures; vs: versus; SNK: Student-Newman-Keuls test; *p<0.05

DISCUSSION

Most participants in this study wore dentures, with predominance of upper or lower removable partial dentures. It was found that denture wearing negatively influenced the electrical activity of masticatory muscles in individuals with PD.

In this study, there was predominance of upper and lower removable partial dentures, unlike another one, which found predominance of full dentures in groups with and without PD[21]. This may be explained by the participants' dental follow-up in a university's outreach program, helping them maintain their teeth. A study in 103 older individuals without degenerative diseases revealed that 66% wore upper and lower dentures, which is in line with the data obtained in the present study[22].

Aging is associated with a decline in masticatory function, reducing the maximum bite force[23] and leading to sarcopenia[24,25]. The chewing pattern differs between denture wearers and toothed individuals[26-28]. This difference was observed in this study in the electromyographic analysis when comparing the group with natural teeth with those who wore different types of dentures, with higher maximum voluntary contraction. It can be considered that fewer teeth decrease the muscle electrical activity, which is not restored even with removable dentures. A similar result confirms the decreased mastication muscle activity when wearing upper and lower removable partial dentures. The decrease in muscle electrical activity may be due to muscle atrophy, which is present in PD patients as a result of motor symptoms that impair the masticatory function[3-29].

DW1 (upper removable partial dentures) was not statistically different from the control. This may be due to the number of teeth lost in the upper arch and the use of a single removable partial denture, making it possible that the muscle electrical activity was similar to the control's maximum voluntary contraction with natural teeth. No data were found in the literature to discuss this finding.

Most individuals who wore upper and lower removable dentures were in stage 1 of the disease, whereas those who wore upper removable dentures were in stages 2 and 3. In the researched literature, no data were found relating the stage of the disease with the type of dentures. However, it has been reported that motor symptoms in the disease influence the quality and frequency of oral hygiene and the use of dentures[30] – which corroborates the statement that oral function worsens with disease stages[31].

The difference found in this study in EMG findings between denture wearers and non-wearers demonstrates that wearing dentures reduces the electrical activity and that the fewer artificial teeth in the dentures, the smaller the loss of muscle strength. These data validate a study on removable partial dentures, full dentures, overdentures, and a control group (natural teeth), in which maximum voluntary contraction was higher in the control group than in the other ones[32]. Moreover, in individuals with PD who wear dentures, masticatory function is affected during the "on" phase of levodopa, with a lower range of mandibular motion, longer duration and lower speed of the masticatory cycle, and weaker bite force[33].

Therefore, managing edentulism, observed in individuals who wear some type of denture, and preserving natural teeth help masticatory function by increasing the bite force, considering a larger number of dentures, which reduces the impact on mastication[34]. Rehabilitation with removable dentures improved oral health-related quality of life, and chewing efficiency was similar to that of the control group[35].

This study has limitations, as it used a nonprobabilistic convenience sample and a secondary database, which hinder a sample calculation. Thus, it was not possible to further analyze the issue. Moreover, there is a scarcity of publications addressing this topic in relation to PD. Longitudinal studies and clinical trials with larger samples should be conducted to elucidate the association of removable denture wearing with the electromyographic activity of masticatory muscles in individuals with PD. Therefore, it is important that dental surgeons maintain oral conditions under control, focusing on prevention and informing individuals with PD and their families about the importance of regular dental visits for oral healthcare.

CONCLUSION

Individuals with PD wearing dentures have their electrical activity masticatory muscles negatively affected when compared with those with PD who do not wear dentures and have natural teeth.

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Author's contribution:

JSO: critical review for relevant intellectual content and data analysis and interpretation;

AVS, TVAS: data acquisition, analysis and interpretation of data;

MGWSC: data analysis and interpretation;

CCSAL: conception and design of the study, critical review for relevant intellectual content and final approval of the version to be submitted for publication.