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# Relationships Between Swallowing Function, Sialorrhea, and Cervical Proprioception in Parkinson's Disease

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## ABSTRACT

**Objective:** In patients with Parkinson's disease (PD), alterations in position sense, swallowing function, and sialorrhea may occur. In neurological disorders, impairment of sensory input from the cervical region has been shown to adversely affect swallowing function. The aim of this study was to investigate the relationship between swallowing function, sialorrhea, and cervical position sense in patients with PD.

**Materials and Methods:** In this cross-sectional study, 55 patients with PD completed assessments of swallowing function using the Turkish version of the Eating Assessment Tool-10, sialorrhea using the Sialorrhea Clinical Scale for Parkinson's Disease, and position sense using a digital inclinometer. The relationships among these variables were evaluated using the Spearman correlation test.

**Results:** A significant correlation was found between swallowing function and sialorrhea ($p<0.05$). However, no correlation was observed between cervical position sense and swallowing function or sialorrhea ($p>0.05$).

**Conclusion:** In conclusion, there was an association between swallowing function and sialorrhea. However, cervical position sense was not associated with these parameters. Future studies should consider these findings, and more comprehensive research including a control group and patients with advanced-stage PD is needed.

**Keywords:** Parkinson's disease, position sense, sialorrhea, swallowing disorders.

## INTRODUCTION

Parkinson's disease (PD) is among the most prevalent neurodegenerative disorders globally and is characterized by a multitude of motor and non-motor symptoms.[1] Swallowing dysfunction develops in most patients during the course of the disease, with prevalence varying according to disease severity. The exact pathology of PD-related swallowing dysfunction remains unclear. However, current evidence suggests that it may be associated with substantia nigra degeneration, dysfunction of the non-dopaminergic system, and neuronal loss in the medullary swallowing pattern generator.[2] Swallowing dysfunction in PD leads to aspiration pneumonia, prolonged hospitalization, increased mortality, and decreased quality of life.[3]

Impaired saliva production and/or control, as well as salivary deficiency or excess, can result in a range of adverse effects, from mild discomfort to significant health and social complications. Control of sialorrhea is impaired in patients with PD and is associated with multiple factors such as dysphagia, orofacial stiffness/hypomimia, lingual bradykinesia, cognitive status, male sex, and disease stage.[4] Additional contributing factors include changes in sensory and postural processes. Despite the identification of numerous contributing factors to sialorrhea in PD, the precise etiology of this phenomenon remains unclear. The strongest evidence supports an established link between dysphagia and sialorrhea.[5] In the cohort study conducted by Perez-Lloret et al.,[5] oro-buccal symptoms such as dysarthria, sialorrhea, and swallowing function were examined. The study revealed that two-thirds of patients with moderate PD exhibited oro-buccal symptoms, and a significant relationship was observed between the occurrence of each symptom and the presence of the other two.

Swallowing is considered a sensorimotor function; it is a process that involves the harmonious interaction of sensory and motor components. Since many structures related to swallowing are located in the cervical region, problems in this region may negatively affect swallowing function. Therefore, proper alignment of the head and neck is extremely important for maintaining the dynamic processes occurring in the cervical region.[6] In addition, the cervical region has a high density of proprioceptors, which play a role in head, neck, and trunk alignment. Impairment of proprioception results in the inability to perform desired motor movements.[7]

Impairment of proprioception in the cervical region can negatively affect swallowing function as well as head and neck movements. Sevim et al.[8] reported a relationship between dysphagia severity and decreased head and neck proprioception in neurological disorders. Although it can be concluded that the sensory receptor system of the cervical region should be taken into consideration, the relationship between head and neck proprioception and swallowing in PD has not been sufficiently investigated in the literature. Therefore, the purpose of this study was to explore the relationship between swallowing function, sialorrhea, and cervical position sense in patients with PD. We hypothesized that there is a relationship between swallowing function, sialorrhea, and cervical position sense in patients with PD.

### KEY MESSAGES

- There is a relationship between swallowing function and sialorrhea in patients with Parkinson's disease.
- There is no relationship between cervical position sense and swallowing function or sialorrhea in patients with Parkinson's disease.
- Future studies are recommended to include patients with advanced-stage PD, as well as a control group, to assess cervical motor function.

## MATERIALS AND METHODS

### Ethical Approval

This cross-sectional study was conducted at Neurology Clinic of Ankara City Hospital. Approval was granted by the Ankara Yıldırım Beyazıt University Health Sciences Ethics Committee (Approval Number: 2023-482, Date: 06.12.2023), and prospective participants were provided with information about the study before their consent was obtained.

### Study Design and Participant Selection

Sample size estimation was performed using G*Power software (version 3.1). Assuming an expected correlation coefficient of 0.50, a significance level (α) of 0.05 and a statistical power of 95%, the required minimum sample size was determined to be 46 participants.[9]

The inclusion criteria were as follows: a diagnosis of PD according to the Movement Disorder Society–Parkinson's Disease (MDS-PD) criteria made by a specialist neurologist; age ≥18 years; and a Standardized Mini-Mental State Examination (SMMSE) score of 24 or higher. The exclusion criteria included the presence of a cervical pathology such as cervical disc herniation or radiculopathy; a history of cervical surgery; a history of neck pain within the previous month; the presence of any visual impairment; and receiving treatment for salivation.

### Measurements

The severity of PD was assessed by a specialist neurologist using the Modified Hoehn and Yahr Scale, and cognitive status was evaluated using the SMMSE. Demographic information,

swallowing function, sialorrhea, and position sense of patients with PD who met the inclusion criteria were evaluated by a physiotherapist. All assessments in patients with PD were conducted during the medication "on" phase to minimize the effects of motor fluctuations. Evaluations were performed approximately 1–2 hours after the intake of dopaminergic medication, when patients were in their optimal functional state.

### Swallowing Function

Symptoms of swallowing disorders were evaluated using the Turkish Eating Assessment Tool (T-EAT-10). The T-EAT-10 is a reliable and valid assessment tool that evaluates swallowing-related symptoms through specific self-reported questions. The test consists of 10 items. The T-EAT-10 is a screening tool that is simple to administer, easy to score, and applicable across a wide range of swallowing dysfunctions. A total score of 3 or higher on the T-EAT-10 indicates a risk of swallowing disorder.[1]

### Sialorrhea

The Sialorrhea Clinical Scale for Parkinson's Disease consists of seven subscales that assess various aspects of salivation in patients with PD. These include diurnal sialorrhea (A), nocturnal sialorrhea (B), severity of drooling (C), speech disturbance (D), eating disturbance (E), frequency of drooling (F), and social disturbance (G). Patients are asked to respond subjectively regarding the extent to which increased salivation has bothered them during the past week. In all seven sections, increased salivation is rated on a scale from 0 to 3. A score of 0 indicates that the patient was not affected by increased salivation at all, whereas a score of 3 indicates that the patient was maximally affected. The lower the total score on the scale, the less the patient is affected by increased salivation.[11] The Turkish reliability and validity of the Sialorrhea Clinical Scale were established by Genç et al.,[12] and it has been reported to be a reliable and valid tool for patients with PD.

### Position Sense

Cervical position sense was measured using the Cervical Joint Position Error Test (CJPET), which employed a Dualer IQ digital inclinometer (J-Tech Medical, Midvale, UT, USA). The digital inclinometer has been shown to demonstrate good test-retest reliability when used to measure spinal range of motion.[13] The test was conducted by the same experienced physiotherapist to ensure consistency. To administer the CJPET, the target head position to be reproduced by the patients was set by the assessor at 50% of the available range of motion (ROM). Patients were instructed to keep their eyes closed during the test. Measurements were performed in two positions:

(1) The sitting position for flexion, extension, and right and left lateral flexion,

(2) The supine position for right and left rotation.

**Table 1.** Sociodemographic characteristics of the patients

| | Median | Minimum-Maximum |
|---|---|---|
| Age (years) | 65 | 45-82 |
| BMI (kg/m$^2$) | 28.23 | 21.72-41.52 |
| | **n** | **%** |
| Gender | | |
| Male | 36 | 65.5 |
| Female | 19 | 34.5 |
| Education level | | |
| Primary school | 26 | 47.3 |
| Secondary school | 4 | 7.3 |
| High school | 9 | 16.4 |
| University | 16 | 29.1 |

n: Number of patients; %: Percentage; kg: Kilogram; m: Meter; BMI: Body mass index.

During the CJPET, the digital inclinometer was positioned at different points on the head: on the lateral aspect for flexion and extension, on the forehead for right and left lateral flexion, and on the vertex while the participant was in the supine position to assess right and left rotation. Each movement direction (flexion, extension, rotation, and lateral flexion) was repeated three times, and the mean of these trials was used for analysis. The absolute error value represented the CJPET outcome measure.[14]

### Statistical Analysis

Data analyses were conducted using IBM SPSS Statistics version 26.0 (SPSS Inc., Chicago, IL, USA). The normality of the variables was examined using visual (histograms, probability plots) and analytical methods (Kolmogorov-Smirnov and Shapiro-Wilk tests). Descriptive data were summarized as frequencies and percentages for categorical variables, and as median (minimum–maximum) and mean (standard deviation) for continuous variables. As the data were non-normally distributed, relationships among variables were analyzed using Spearman's correlation test. Statistical significance was set at a p-value <0.05.

## RESULTS

A total of 55 patients with PD (median age=65 years, min/max= 45/82 years; 65.5% male) were included in the study. The sociodemographic characteristics of the patients are presented in Table 1.

The median disease duration was 6 years, and the median disease stage was 1.5. Intraoral anatomical structures were missing in 33 (60%) patients. In addition, 11 (20%) patients exhibited chewing difficulties, and 13 (23.6%) reported cough symptoms. The clinical features of the patients are detailed in Table 2.

A positive, moderate, and statistically significant correlation was found between swallowing function and sialorrhea (rho=0.618, p<0.001). There was no significant relationship between swallowing function and any parameter of cervical position sense (p>0.05). Similarly, no significant relationship was detected between sialorrhea and any cervical position sense parameters (p>0.05) (Table 3).

## DISCUSSION

According to the findings of our study, greater sialorrhea severity was associated with increased swallowing dysfunction. However, cervical position sense was not related to either swallowing function or sialorrhea.

Swallowing dysfunction is frequently observed in patients with PD and can occur at all stages of the disease. It is estimated that 40-80% of patients with PD worldwide experience swallowing problems.[15] Hallmarks of swallowing dysfunction in patients with PD include festinated or repetitive tongue movements (also called tongue pumping),[16] decreased chewing speed and coordination, significantly prolonged oropharyngeal transit time, and pharyngeal spill.[17] In the study known as the Barcelona and Lisbon cohort, it was reported that the prevalence of swallowing dysfunction was 68% in patients with PD at Hoehn and Yahr stages 4 and 5.[18] These data indicate that swallowing problems increase in the later stages of the disease. This may result from a sustained reduction in dopaminergic activity in advanced PD. The results of our study showed that the EAT-10 scores of patients with early-stage PD averaged 3±6, indicating a risk of swallowing dysfunction.

Another clinical symptom observed in patients with PD is sialorrhea. Sialorrhea is essential for preserving oral health

**Table 2.** Clinical characteristics of the patients

| | Median (Min-Max) | Mean±SD |
|---|---|---|
| Disease duration (years) | 6 (1-20) | 7.6±4.9 |
| Hoehn and Yahr stage | 1.5 (1-5) | 1.6±0.9 |
| Standardized mini-mental state examination (score) | 27 (24-30) | 27±2 |
| Turkish eating assessment Tool-10 (score) | 0 (0-30) | 3±6 |
| Sialorrhea clinical scale for Parkinson's Disease (score) | 2 (0-14) | 3±4 |
| Position sense | | |
| Cervical flexion JPE (°) | 2.66 (0-6.33) | 2.44±1.51 |
| Cervical extension JPE (°) | 2 (0.33-8) | 2.56±1.58 |
| Cervical right lateral flexion JPE (°) | 2 (0.33-8.33) | 2.45±1.61 |
| Cervical left lateral flexion JPE (°) | 2.33 (0-6.33) | 2.58±1.49 |
| Cervical right rotation JPE (°) | 2.33 (0.33-5.33) | 2.38±1.26 |
| Cervical left rotation JPE (°) | 2.17 (0.33-6.66) | 2.38±1.47 |
| | **n (%)** | **%** |
| Turkish eating assessment Tool-10 (score) | | |
| ≥3 | 18 | 32.7 |
| <3 | 37 | 67.3 |
| Cough after eating/drinking | | |
| Yes | 13 | 23.6 |
| No | 42 | 76.4 |

Min: Minimum; Max: Maximum; SD: Standard deviation; n: Number of patients; %: Percentage; JPE: Joint position error.

**Table 3.** Correlations between swallowing function, saliva, and cervical position sense

| | T-EAT-10 | | SCS-PD | |
|---|---|---|---|---|
| | rho | p | rho | p |
| SCS-PD (score) | 0.618 | **<0.001*** | – | – |
| Position sense | | | | |
| Cervical flexion JPE (°) | -0.107 | 0.436 | -0.126 | 0.359 |
| Cervical extension JPE (°) | 0.005 | 0.973 | -0.083 | 0.549 |
| Cervical right lateral flexion JPE (°) | -0.078 | 0.570 | -0.007 | 0.962 |
| Cervical left lateral flexion JPE (°) | -0.096 | 0.485 | -0.128 | 0.351 |
| Cervical right rotation JPE (°) | 0.061 | 0.667 | 0.090 | 0.524 |
| Cervical left rotation JPE (°) | -0.152 | 0.282 | -0.037 | 0.794 |

T-EAT-10: Turkish Eating Assessment Tool-10; SCS-PD: Sialorrhea Clinical Scale for Parkinson's Disease; JPE: Joint position error; r: Spearman's correlation coefficient; *p<0.05.

and plays a crucial role in facilitating swallowing.[19] Xerostomia is observed in approximately 50% of patients with PD, and similarly, sialorrhea is reported in approximately 50% of cases.[20] Although sialorrhea appears to result from excessive saliva production, the primary underlying cause is a reduction in the frequency of spontaneous swallowing.[21] Patients with PD have been shown to swallow 39% less frequently than young healthy controls.[22] In addition, poor head control, a persistently open mouth, inadequate lip control, irregular tongue mobility, decreased tactile sensation, macroglossia, dental malocclusion, and nasal congestion have been identified as causes of sialorrhea.[23] However, many patients with PD may be unaware of their swallowing or sialorrhea problems, possibly due to deficits in proprioception.[8,24] Sensory dysfunction, such as impaired proprioception, may reduce an individual's ability to recognize sialorrhea. Similarly, anatomical or motor dysfunction related to swallowing may limit the ability to manage increased secretions. A cohort study examining the prevalence and clinical associations of sialorrhea and swallowing dysfunction in patients with PD reported that sialorrhea was more prevalent in patients with Unified Parkinson's Disease Rating Scale (UPDRS) II + III scores higher than 28 and in those with swallowing dysfunction.[5] In the present study, sialorrhea showed a positive correlation with swallowing dysfunction, and our findings are consistent with the literature.

Research has indicated that cervical proprioception plays a crucial role in various neurological disorders. Impaired cervical proprioception may disrupt body orientation and lead to insufficient stabilization of the head and neck muscles during swallowing.[25,26] Edwards et al.[26] demonstrated that cervical proprioceptive input has direct neural connections with brainstem swallowing centers. Using an experimental animal model, they showed that sensory afferents from the upper cervical region project to the intermedius nucleus of the medulla, which in turn connects with key nuclei responsible for tongue, pharyngeal, laryngeal, respiratory, and autonomic control. Functional findings indicated that stimulation of cervical afferents can modify brainstem motor output and respiratory patterns. These results suggest that cervical proprioception is neurally integrated into the swallowing network and may influence swallow initiation, coordination of oropharyngeal movements, and airway protection. There are numerous studies in the literature examining swallowing problems and sialorrhea in patients with PD;[21,27] however, no study has yet investigated the relationship between cervical position sense and swallowing function or sialorrhea in this population. A discrepancy of 4-5 degrees or more in position sense measurement is considered indicative of impaired cervical position sense. In the present study, the mean cervical position sense errors were as follows: flexion, 2.66; extension, 2.00; right and left lateral flexion, 2.00-2.33; right and left rotation, 2.33-2.17. Furthermore, Abakay et al.[28] investigated the relationship between cervical proprioception and dysphagia severity in patients with multiple sclerosis. They reported that significant proprioceptive deficits were associated with increased swallowing difficulties, suggesting that pronounced position sense impairment may contribute to dysphagia severity. Our findings indicate that the magnitude of position sense errors was insufficient to suggest the presence of a position sense disorder. Therefore, the lack of correlation between cervical position sense and both swallowing function

and sialorrhea may be attributable to this relatively preserved function. This finding may also suggest that the primary factors contributing to swallowing impairment and sialorrhea in patients with PD are motor deficits rather than sensory impairments, such as deficits in position sense.

This study has several limitations. First, dysphagia risk was assessed using self-report measures rather than objective imaging techniques, such as videofluoroscopic or fiberoptic endoscopic evaluation, which are considered gold-standard methods. Although self-reported questionnaires provide valuable information regarding patients' perceived swallowing difficulties, they may not fully capture subclinical or physiological aspects of dysphagia. Second, the mean disease severity of the participants with PD was 1.5, which may limit the generalizability of the findings. It is possible that the relationship between cervical position sense and swallowing function may differ in patients with more advanced disease severity.

## CONCLUSION

In patients with Parkinson's disease, swallowing dysfunction is associated with sialorrhea, whereas cervical position sense does not appear to be related to either swallowing function or sialorrhea. These findings suggest that interventions targeting swallowing function may also contribute to the management of sialorrhea. Future studies should consider including patients with advanced-stage PD, as well as a control group, to further evaluate cervical motor function.

**Ethics Committee Approval:** Approval was granted by the Ankara Yıldırım Beyazıt University Health Sciences Ethics Committee (Approval Number: 2023-482, Date: 06.12.2023).

**Informed Consent:** Informed consent was obtained from the participants.

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