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Assessment of the Sensitivity of the Vocal Tract in Parkinson Disease by Nasal Video Endoscopy

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Abstract

Introduction Sensory deficits of the upper airways are common in people with Parkinson disease. Compounded by considerable deterioration of the swallowing function, these deficits may contribute to the elevated rates of morbidity and mortality among this population.

Objective To examine the sensitivity of the vocal tracts of people with Parkinson disease using nasal videoendoscopy and to compare the results with paired controls.

Methods The present was a prospective, observational, case-control study. Sensitivity assessments were conducted in a sample of 24 people divided into 2 groups: one group of 12 patients with Parkinson's disease, and a control group with 12 healthy subjects. The study group also underwent a fiberoptic endoscopic evaluation of swallowing and answered the Swallowing Disturbance Questionnaire (SQD) to detect dysphagia.

Results There was a significant difference ($p < 0.05$) in the region of the arytenoid cartilages, showing that sensitivity was better preserved among the control group, and that sensitivity deficits were present in the study group. The qualitative results showed sensorial impairment in the study group than in the control group regarding the base of the tongue, the vestibular folds, and the vocal folds. The study group showed self-awareness regarding the deficits in the swallowing function, but there was no statistically significant association between swallowing function deficits and deterioration of sensorial function among them.

Conclusions Sensorial deficits were present in the study group when compared to the healthy subjects, mainly in the qualitative evaluation.

Keywords

- nervous system diseases
- endoscopy
- deglutition
- swallowing disorders

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Introduction

Dysphagia is a symptom often observed in patients with Parkinson disease (PD), and it could be related, in some of the patients, to penetration and aspiration of liquids or foods into the lower respiratory tract. Laringotracheal aspiration increases the risks of malnutrition, dehydration, pulmonary complications, and mortality in this population.[1–4]

Swallowing is a mechanism involving events that are controlled and coordinated intrinsically to prevent the entry of any type of substance into the airways.[5] Sensory input is vital to ensure that these biomechanics take place correctly, since the ability to effectively protect the airways is dependent on multiple behaviors that prevent materials of any type from entering the lower respiratory tract.[6] The functionality of airway protection mechanisms is particularly important in PD, since aspiration bronchopneumonia is the most common cause of death among those patients.[7–10]

While the considerable impact of dysphagia on morbidity, mortality, and quality of life is clear, its correlations with the severity of PD and its pathophysiological mechanisms are still controversial. Swallowing difficulties in this population are the result of a combination of rigidity and bradykinesia, lack of respiratory coordination, and sensory deficits in the pharynx.[11,12]

Protective reflexes are paramount to airway protection. One of the most important is coughing, which is defined as a sensory behavior, a reflexive response of the brainstem that protects the airways from the entrance of foreign bodies and which can also be triggered voluntarily. More severely compromised motor control in terms of coughing can cause a substantial deficit in the protection mechanisms responsible for clearing the airways.[13–15] The organization and efficacy of the cough reflex can provide information about swallowing dysfunctions. Recent studies[9,16–18] have demonstrated that airway protection mechanisms are negatively affected in PD, and that the cough reflex is attenuated in this population.

The traditional focus of the clinical assessment and treatment of patients with dysphagia is the motor component of swallowing, but, more recently, sensitivity assessments of the region of the laryngopharynx have been used to determine the degree of compromise of sensory input in different populations.[19–22] In PD, the results of sensitivity testing are convergent with the fact that this population present a significant compromise in swallowing control suggesting that these patients may suffer from upper airway sensorial deficits. Sensory impairement contributes to silent aspiration and to the high rates of mortality from aspiration pneumonia.[23,24]

It is important to conduct several studies and develop a valid, practical, and reliable method to identify airway protection deficits. Early signs detected during laryngopharyngeal sensorial evaluation could have an impact on the best practices used by the rehabilitation teams, enabling a precise diagnosis and management for patients with PD.

The objective of the present study was to analyze the somatosensory function of the airways in PD patients using a fiberoptic endoscopic evaluation of swallowing (FEES) and comparing the results with matched controls. The study also attempted to demonstrate an association between this function and the risk of dysphagia. The research hypothesis is that, when compared with healthy individuals, PD patients would exhibit sensory deficits thershold and reduced awareness of swallow deficits.

Materials and Methods

The present is a case-control study. The research project was evaluated and approved by the Scientific Commission and Ethics in Research Committee of our institution.

A sample size calculation was performed using the WinPEPI computer programs for epidemiologists, version 11.43, based on data from a study by Onofri.[25] To achieve a significance level of 5% with 80% of power, the minimum number of subjects needed was 24.

We performed a comparative analysis of two distinct groups of participants: the study group (SG) with 12 PD patients selected from a database of the Neurology Service of a tertiary hospital in the city of Porto Alegre, Southern Brazil, and the control group (CG) was 12 healthy subjects recruited in the community.

The 24 participants were assessed and matched based on age and gender. The patients recruited for the SG had PD diagnosed more than three years previously, at stages II, III, or IV according to the Hoehn and Yahr Scale, and with no history of any other neurological or psychiatric disorders. The participants recruited for the CG were selected during a semi-structured interview on general health status and history of diseases, were in good general health, and did not have any swallowing disorders and/or history of neurological diseases. All of the participants were non-smokers and did not have lung diseases, and they received information on the risks and benefits of the procedures to be performed as part of the study. All individuals agreed to participate and signed the informed consent form.

During the first stage of the study, each participant's self-awareness of dysphagia was assessed using the Swallowing Disturbance Questionnaire (SDQ), which was developed for dysphagia screening in PD patients by Manor et al.[26] and validated in Brazil by Ayres et al.[27]

The participants then underwent FEES based on its protocol[28] with modifications (►**Supplementary Material**), and the evaluation was Conducted by a single otorhinolaryngologist (OT) with the presence of a speech and language therapist (SLT). The examination was performed using a flexible optical fiber, which was introduced into the nasal cavity, without the administration of a topical local anesthetic, thus avoiding interference in the laryngopharyngeal sensitivity.[29]

During the procedure, the OT conducted a detailed assessment of the structures that included the anatomy of the vocal tract, since the endoscope provides a panoramic view of the nasopharynx and laryngopharynx. Initially, the lateral and posterior walls of the pharynx, the base of the tongue, the vallecula, the epiglottis, the piriform sinuses, the vestibular vocal folds, and the vocal folds were analyzed at rest position. Passive observation of this region enables the determination of the presence/absence of preexisting salivary stasis and the identification of tremors and involuntary movements of the pharynx and larynx, in addition to the identification of tumors and asymmetries. After the passive examination, the participant was requested to enunciate the vowel sound /e/ for the investigation of the mobility of the vocal folds. Subsequently, swallowing was evaluated directly with a liquid (3 mL and 5 mL of water with a blue dye measured in a syringe and offered in a small plastic spoon), a puree, (3 mL and 5 mL of thickened water with a blue dye measured in a syringe and offered in a small plastic spoon) and solid food (5 cm^2 of cream cracker biscuit with a blue dye). The volumes and the consistencies were based on the Dysphagia Risk Evaluation Protocol (DREP).[30]

Each bolus was assessed based on the observation of the passage through the oropharynx and on airway protection. The outcomes related to the passage through the oropharynx were posterior spillage of the bolus and presence/absence of pharyngeal residue. The airway protection outcomes were presence/absence of laryngeal penetration and presence/absence of laryngotracheal aspiration.

The vocal tract sensitivity test was the last step of the FEES. Sensitivity was assessed by touching the base of the tongue, the epiglottis, the arytenoid cartilages, and the piriform sinuses each side at a time with the distal end of the endoscope. Depending on the tolerance of the individual, the vestibular vocal folds were also assessed.

Sensitivity was described as present if any of the following events occurred: cough reflex, gag reflex, or laryngeal adductor reflex (LAR). It was described as absent if none of these events occurred. The findings from these assessments were all based on the Vocal Tract Sensitivity Assessment Protocol (►**Supplementary Material online**) developed by the institutional SLT team and the researchers.

The sensitivity outcomes were classified as absent, present unilaterally, present bilaterally, or not assessed, if the participant could not tolerate the touch of the endoscope to the structure. Three SLTs with experience in dysphagia evaluated the exams, and the results were classified by consensus. This analysis was conducted using digital video disc (DVD) recordings of the evaluations.

Regarding the statistical analysis, the quantitative variables were expressed as means and standard deviations, and the categorical variables, as absolute and relative frequencies. The Pearson Chi-squared test with adjusted residuals was used to analyze the associations among the categorical variables. Agreement between the risk of dysphagia and the observed dysphagia was analyzed using Kappa coefficients. The Cochran test was used to assess the associations involving laryngeal sensitivity and endoscopic findings. A probability of alpha error < 0.05 was considered statistically significant. and the analyses were performed using Statistical Package for the Social Sciences (IBM SPSS Statistics for Windows, IBM Corp., Armonk, NY, United States) software, version 21.0.

Results

The sample included 12 subjects in each group, in a total of 5 (41.7%) women and 7 (58.3%) men. The mean age of the SG was of 63.5 ($\pm$ 9.7) years, and among the CG, it was of 63.4 ($\pm$ 9.8) years. According to the Hoehn and Yahr Scale, 7 (58.3%) SG participants were at stage II, 3 (25%) were at stage III, and 2 (16.6%) were at stage IV.

In all 24 (100%) subjects assessed, no abnormalities were observed in the nasal cavity or the nasopharynx. Furthermore, none of them exhibited any organic or functional disorders of the vocal folds in the laryngeal assessment.

With regards to the correlations between the perception of dysphagia in the SG and the presence/absence of dysphagia, 6 (50%) participants exhibited risk of dysphagia according to the SDQ and presented dysphagia based on the FEES. All of these 6 participants at risk of dysphagia did exhibit dysphagia (100%), whereas 4 (66.7%) of the 6 participants not at risk of dysphagia according to the SDQ did not exhibit dysphagia, equating to an agreement of 83.3% (Kappa = 0.7; $p = 0.014$).

►**Tables 1**, **2**, and **3** show the correlations regarding laryngeal sensitivity and the endoscopic findings in terms of swallowing for the three different food consistencies (puree, liquid, and solid) in the SG.

►**Table 1** shows that 7 SG participants exhibited alteration in their response with the puree consistency on the FEES. In contrast, the results for both liquid and solid consistencies,

Table 1 Associations between laryngeal sensitivity and endoscopic findings on swallowing with puree consistency in the study group ($n = 12$)

Variables of the FEES findings	Sensitivity				
	Absent: *n* (%)	Present bilaterally: *n* (%)	Present unilaterally: *n* (%)	No tolerance to endoscope touch: *n* (%)	*p*
Posterior Spillage ($n = 4$)	2 (50.0)	2 (50.0)	0 (0.0)	0 (0.0)	> 0.05
Pharyngeal residue ($n = 3$)	1 (33.3)	0 (0.0)	1 (33.3)	1 (33.3)	> 0.05
Laryngeal penetration ($n = 0$)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	> 0.05
Aspiration ($n = 0$)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	> 0.05

Abbreviation: FEES, fiberoptic endoscopic evaluation of swallowing.
Note: Source: Machado (2018). *Cochran Test.

Table 2 Associations between laryngeal sensitivity and endoscopic findings on swallowing with liquid consistency in the study group ($n = 12$)

Variables FEES Findings	Sensitivity				
	Absent: *n* (%)	Present bilaterally: *n* (%)	Present unilaterally: *n* (%)	No tolerance to endoscope touch: *N* (%)	*p*
Posterior Spillage ($n = 10$)	5 (50.0)	5 (50.0)	0 (0.0)	0 (0.0)	> 0.05
Pharyngeal residue ($n = 4$)	2 (50.0)	1 (33.3)	1 (33.3)	0 (0.0)	> 0.05
Laryngeal penetration ($n = 3$)	1 (33.3)	1 (33.3)	0 (0.0)	1 (33.3)	> 0.05
Aspiration ($n = 1$)	1 (100)	0 (0.0)	0 (0.0)	0 (0.0)	> 0.05

Abbreviation: FEES, fiberoptic endoscopic evaluation of swallowing.
Note: Source: Machado (2018). *Cochran Test.

Table 3 Associations between laryngeal sensitivity and endoscopic findings on swallowing with solid consistency in the study group ($n = 12$)

Variables FEES Findings	Sensitivity				
	Absent: *n* (%)	Present bilaterally: *n* (%)	Present unilaterally: *n* (%)	No tolerance to endoscope touch: *n* (%)	*p*
Posterior Spillage ($n = 9$)	4 (44.4)	5 (55.5)	0 (0.0)	0 (0.0)	> 0.05
Pharyngeal residue ($n = 7$)	1 (14.3)	4 (57.1)	1 (14.3)	1 (14.3)	> 0.05
Laryngeal penetration ($n = 0$)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	> 0.05
Aspiration ($n = 0$)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	> 0.05

Abbreviation: FEES, fiberoptic endoscopic evaluation of swallowing.
Note: Source: Machado (2018). *Cochran Test.

shown in ►**Tables 2** and **3** respectively, revealed response alterations for all participants, and some exhibited more than one alteration for the same consistency.

Relating the participants' sensitivity with liquid consistency outcomes, 3 participants exhibited laryngeal penetration, which was classified as silent in 1 (33.33%) case, and 1 (33.33%) participant exhibited laryngotracheal aspiration, which was also silent. When given pureed and solid food, none of the SG participants exhibited laryngeal penetration or tracheal aspiration.

Spillage was the swallowing outcome most often observed, regardless of the consistency of the food. Most of the participants presented pharyngeal residue with solid food. These results were not related to an impaired sensitivity in the tested regions. None of the variables described in ►**Tables 1**,**2**,**3** exhibited statistical significance in the SG.

The comparison of the sensitivity test between the two groups revealed no significant differences ($p > 0.05$), except for the sensitivity assessment of the arytenoid cartilages, in which the CG had a lower rate of tolerance to the assessment than the SG. Additionally, based on a qualitative comparison, 5 SG participants showed an absence of sensitivity on the base of the tongue, while the CG showed no alterations. When observing the results of the tolerance to the touch of the endoscope to the laryngeal structures, 7 SG participants showed no tolerance in the left and right vestibular folds, while 11 CG subjects had the same outcome; and, in the left and right vocal folds, 9 SG participants and 11 CG participants did not tolerate the touch of the endoscope.

These results indicate a more preserved sensitivity in the CG compared to the SG, suggesting that sensitivity disorders are more present in participants with PD, even though most of the results of the present study were not statistically significant. The results for the sensitivity classification of the structures analyzed in both groups are shown in ►**Table 4**.

Discussion

Swallowing is a complex and coordinated function that is extremely dependent on afferent sensory information. Deficiencies in this information are one of the major causes of dysphagia. The importance of sensitivity to swallowing has been investigated by many researchers. Regarding PD, there are studies showing that reduced laryngeal sensitivity is relevant to laryngeal penetration and aspiration.[9,10,16]

Sensitivity abnormalities in the oropharynx and larynx can be assessed; however, most of the studies[20,21,31,32] used endoscopes adapted with outlets to deliver air pulses. In contrast, the sensory assessment conducted in the present study was based on a study by Langmore et al.[28] (1998), who described the FEES. In their original study, these authors[28] described the importance of conducting sensory testes to the

Table 4 Intergroup comparisons for the anatomic parameters assessed in the sensitivity test ($n = 24$)

Variables	Study group $N = 12$ (50%)	Control group $n = 12$ (50%)	p
Base of the tongue			0.155
Absent	5 (41.7)	1 (8.3)	
Present bilaterally	7 (58.3)	11 (91.7)	
No tolerance to endoscope touch	0 (0.0)	0 (0.0)	
Epiglottis			1.000
Absent	1 (8.3)	0 (0.0)	
Present bilaterally	11 (91.7)	12 (100)	
No tolerance to endoscope touch	0 (0.0)	0 (0.0)	
Right piriform sinus			0.180
Absent	2 (16.7)	0 (0.0)	
Present	9 (75.0)	12 (100)	
No tolerance to endoscope touch	1 (8.3)	0 (0.0)	
Left piriform sinus			0.496
Absent	2 (16.7)	0 (0.0)	
Present	9 (75.0)	10 (83.3)	
No tolerance to endoscope touch	1 (8.3)	2 (16.7)	
Right arytenoid			0.038
Absent	1 (8.3)	0 (0.0)	
Present	9 (75.0)*	4 (33.3)	
No tolerance to endoscope touch	2 (16.7)	8 (66.7)*	
Left arytenoid			0.038
Absent	1 (8.3)	0 (0.0)	
Present	9 (75.0)*	4 (33.3)	
No tolerance to endoscope touch	2 (16.7)	8 (66.7)*	
Right vestibular fold			0.158
Absent	1 (8.3)	0 (0.0)	
Present	4 (33.3)	1 (8.3)	
No tolerance to endoscope touch	7 (58.3)	11 (91.7)	
Left vestibular fold			0.158
Absent	1 (8.3)	0 (0.0)	
Present	4 (33.3)	1 (8.3)	
No tolerance to endoscope touch	7 (58.3)	11 (91.7)	
Right vocal fold			0.465
Absent	1 (8.3)	0 (0.0)	
Present	2 (16.7)	1 (8.3)	
No tolerance to endoscope touch	9 (75.0)	11 (91.7)	
Left vocal fold			0.465
Absent	1 (8.3)	0 (0.0)	
Present	2 (16.7)	1 (8.3)	
No tolerance to endoscope touch	9 (75.0)	11 (91.7)	

Notes: Source: Machado (2018). *Pearson Chi-squared test. #Statistically significant association according to the adjusted residuals test (5% significance).

laryngopharyngeal region as part of FEES, suggesting that the end of the endoscope should be used to gently touch the walls of the pharynx, the laryngeal surface of the epiglottis, the aryepiglottic folds, the arytenoid cartilages, and/or the vocal folds to determine sensitivity. The present study analyzed the responses of two groups, and assessed the sensitivity of the laryngopharyngeal tract.

A study by Hammer et al.[23] compared the sensory responses of participants with PD and healthy subjects using an assessment method described by Aviv et al.[32] called Fiberoptic Endoscopic Evaluation of Swallowing with Sensory Testing (FEESST), in which the tester attempts to observe the LAR when pulses of air are delivered to the region of laryngeal mucosa over the arytenoid cartilage. In that study,[23] the participants with PD exhibited somatosensory function in the airways compared with the healthy subjects. the present study diverges from that study, since, in the comparison of the sensory response between the two groups, a significant difference was only observed on the region of the arytenoid cartilages. There are few studies in the literature studying sensitivity assessment, but they use the technique suggested by Langmore et al.[28] However, no studies using this technique in PD participants were identified in the literature.

Based on the physiology of swallowing, during the oral phase, the anterior part of the tongue (2/3 of the whole body of the tongue) is the role of the sensory branch of the facial nerve (VII). The sensory input is determined by pressure and touch receptors, which perceive bolus consistency, volume, and temperature, for example. Diminished sensation in the region of the tongue leads to difficulties in the perception of those features. Additionally, the reflex delay of swallowing is impaired as well in case of the diminished sensation in the tongue. The swallowing reflex is considered the most complex reflex elicited by the central nervous system.[5,6]

In the pharyngeal phase of swallowing, sensory receptors are concentrated in the supraglottic mucosa close to the arytenoid cartilages and cell bodies, and sensory stimuli are transmitted to the reticular formation of the brainstem through the glossopharyngeal (IX) and vagus (X) nerves. Diminished sensation in those areas leads to a reduction in the palatal and pharyngeal (gag) reflexes. The superior laryngeal nerve branch transmits general sensation to the laryngopharyngeal mucosa, the epiglottis, the mucosa above the vocal folds, and the laryngeal joint receptors; therefore, it can affect the ability to protect the entry of any material into the larynx and trachea.[6,19]

Dysphagia is considered one of the clinical symptoms of PD, and studies[23] in the literature report that this symptom is partly caused by reduced sensory input information needed for the adequate biomechanics of swallowing. In the sample of the present study, posterior spillage and pharyngeal residue were the most common endoscopic findings of the functional swallowing assessment, and these may also be associated with altered sensitivity, since they indicated delay triggering the swallowing reflex and reduced sensitivity for spontaneous clearance of the vocal tract. Disintegration of the automatic and voluntary movements, caused by akinesia, bradykinesia, and rigidity associated with PD, can impact biomechanics swallowing, and motor sensory incapacity associated with afferent input may also be the cause of the deficit in initiating swallowing and the delay on the swallowing reflex. Delays initiating the phases of swallowing, more precisely, the delay in the swallowing reflex to initiate the pharyngeal phase, may increase the likelihood of bolus stasis in the vallecula and piriform sinuses, increasing the risk of laryngeal penetration and/or aspiration.[33]

The capacity to effectively protect the airway is dependent on multiple behaviors, and coughing is the main one. Studies published recently demonstrate that the coughing reflex or voluntarily cough is degraded in PD participants. providing evidence of airway protection deficits among this population. As a consequence of the poor sensorimotor integration, unawareness of the presence or severity of dysphagia is often described in PD participants.[17,23,34,35] It may, therefore, seem surprising that most PD participants in the present study were aware of their deficits. This finding may be related to not having selected a particular PD stage. The literature is divergent in terms of the extent to which degree of dysphagia is related to disease progression. Some studies[23,34] report that dysphagia progresses silently, and clinical complaints generally emerge at later and more advanced stages, when there are fewer options for rehabilitation. On the other hand, studies[36] state that it is not possible to establish parallels between staging and swallowing disorders. It would be interesting to include an analysis of the follow-up throughout the PD stages in future investigations, in order to follow the progression of dysphagia in relation to the severity of PD in its different phases and of somatosensory disorders.

However, the fact that members of the SG were aware of their swallowing difficulties coincides with the low rates of laryngeal penetration and tracheal aspiration in the sample, given that loss of sensitivity in the larynx causes a greater occurrence of penetration and aspiration, which are all situations that can lead to clinical complications such as dehydration, malnutrition, and pneumonia due to laryngotracheal aspiration.[9,10,32]

Several methods are employed to diagnose dysphagia, including the FEES, which is considered one of the gold standard methods for an objective and safe assessment. It also enables the assessment of the sensory input of the vocal tract, since the instrument can be used to directly stimulate the pharyngeal and laryngeal regions. As aforementioned, the technique usually described in studies[32] involves using pulses of air. In the current study, the presence or absence of sensitivity was analyzed by touching specific regions with the distal end of the endoscope. It is important to point out that this technique was chosen because standard nasal endoscopes are more likely to be available at public healthcare centers, since most of these services do not have equipment with the accessory needed to deliver air pulses. The comparison of the sensory function of people with PD and healthy subjects exhibited low significance. This finding could be due to the method of evaluation with the endoscope, which may be a strong stimulus when compared with air pulses, so participants with reduced or absent sensitivity nevertheless responded positively. A small sample could be a limitation to a significant result.

A routine clinical examination of the sensory input of PD participants is a must since dysphagia is one of the main symptoms of the disease. The method described by Aviv et al.,[32] using air pulses, requires an accessory to be fitted to endoscopes, which is not viable in many settings. However, the method employing touching with the distal end of the endoscope is possibly not the most effective. Additional studies with this method and larger samples will be needed to reach definitive conclusions on the reliability of the results observed.

Limitations

The probable main limitation of the present study was the subjective assessment carried out by the OT with the endoscope touching the laryngopharyngeal structures of the individuals. The site to be touched and the way of doing it may have differed slightly among the participants, which could have interfered in our results. Additionally, the low level of significance between the two groups may be explained by the small sample size and the survival bias, which means that the less impaired participants were assessed participants, who was able to go to the hospital to take part in the study.

Conclusions

After comparing the sensitivity in the pharyngeal and laryngeal regions of PD participants with matched controls using the method adopted for the present study, the results observed for the region of the arytenoid cartilages showed that the PD participants had sensory deficits. The qualitative evaluation showed distinct results on the base of the tongue, the vestibular folds, and the vocal folds when comparing both groups; however, no statistical significance was observed. Therefore, for the technique herein described, we suggest that future investigations with larger samples of PD participants should be considered, as well as the disease staging, to follow-up the progression of the dysphagia related to PD severity and its distincts stages.

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Conflict of Interests
The authors have no conflict of interests to declare.

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