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Is the Munich dysphagia Test–Parkinson's disease (MDT-PD) a valid screening tool for patients at risk for aspiration?

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ABSTRACT

Background: Dysphagia is common in Parkinson's disease (PD) and leads to pneumonia, malnutrition, and reduced quality of life. For detecting dysphagia-exposed PD patients, the Munich dysphagia test–Parkinson's disease (MDT-PD) is a patient self-reported tool that has been developed specifically for PD patients. The MDT-PD is available in both German and English. This study aimed to ascertain whether the MDT-PD can detect aspiration in PD patients and, therefore, serve as a suitable screening tool.

Methods: In a controlled, cross-sectional, observational study, a total of 119 PD outpatients were examined clinically and were evaluated by the MDT-PD and the one swallowing question (NMS-3) from the nonmotor symptom questionnaire for Parkinson's disease (NMSQuest). The results of the MDT-PD and the NMS-3 were compared to the penetration-aspiration scale (PAS) rating defined by flexible endoscopic evaluation of swallowing (FEES).

Key results: Half of the patients with aspiration as determined using FEES were not detected by the MDT-PD and NMS-3 self-reported tools. The proportion of false positive patients was high with both tools. The sensitivity of the MDT-PD to detect patients who are at risk for aspiration is insufficient (0.37) and not superior to applying the dysphagia screening question from the NMSQuest (0.5).

Conclusion: This study reveals that the MDT-PD is not suitable for detecting aspiration in PD patients and, therefore, cannot be considered as a screening tool for aspiration. However, at present, there is no alternative validated screening tool that can reliably detect aspiration in PD patients. A readjustment of the MDT-PD is urgently needed.

1. Introduction

Dysphagia is very common in patients with advanced Parkinson's disease (PD) but can also occur early in the disease course [1]. Dysphagia reduces the quality of life and presents a risk for serious pneumonia with increasing mortality [1–3]. Moreover, cough behavior seems to be impaired in PD patients, especially in those with existing dysphagia [4,5], which has a direct impact on aspiration. Swallowing problems are usually perceived by the patient and the caregivers late in the disease course and are only reported when patients are specifically asked about swallowing [6]. In a semi-structured interview, only 16–24% of the PD patients acknowledged swallowing difficulties [7,8]. A clear mismatch between subjective and objective severity of dysphagia has been found in PD patients, with silent aspiration having even been detected early in the disease course [1]. Therefore, demand-oriented and resource-saving screening tools for identifying PD patients with potentially harmful dysphagia—such as risk for aspiration—are needed but are rare [9]. Even for patients without Parkinson's disease, there is no standard for a reliable screening tool for dysphagia, be it a questionnaire or a bedside test [10]. Finding a reliable tool for patients with the same disease could be the first step for a disease-independent dysphagia detection tool.

One commonly applied Parkinson-specific and validated screening tool, which is available in English and German, is the Munich dysphagia

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test–Parkinson's disease (MDT-PD) [11]. This patient self-reported tool was developed for the early detection of PD patients with potential swallowing problems to determine the aspiration risk and assess dysphagia with objective methods like FEES subsequently. However, in clinical practice, we had noticed discrepancies in the results regarding aspiration risk when applying the MDT-PD and the objective flexible endoscopic evaluation of swallowing (FEES) in the same patient. In this context, we noticed that the FEES-findings of patients with risk for aspiration or the data from other objective methods evaluating dysphagia, such as videofluoroscopy, were not reflected in the MDT-PD validation study [11].

In this study, therefore, we aimed primarily to evaluate the validity of the MDT-PD against FEES, which is a gold standard method for assessing dysphagia. We wished to ascertain whether the MDT-PD is suited to detect aspiration in PD patients and, therefore, useful as a screening tool for potentially harmful dysphagia without provoking too many unnecessary examinations. We also assessed whether the one swallowing-related question (NMS-3) from the nonmotor symptoms questionnaire for Parkinson's disease (NMSQuest) [8] could detect FEES-proven aspiration. In addition, we assessed how the sensitivity and specificity of MDT-PD and NMS-3 differ.

2. Material and methods

This prospective cross-sectional, observational study was conducted at the University Medical Center Hamburg-Eppendorf between March 30 and May 5, 2016. The study was approved by the local ethics committee of the Medical Council Hamburg (trial number PV5089). A total of 80 men and 39 women with diagnosed PD according to the UK brain bank criteria [12] were examined at a single visit in our movement disorders outpatient clinic in clinical "on" state. The demographic and clinical data are shown in Table 1. All patients were recruited unselectively and consecutively and underwent clinical examination, including FEES directly afterward, irrespective of self-reported swallowing problems. Assessments were done in the same session in clinical "on" state and in case of objective and/or subjective end-of-dose situation, patients were asked to take their medication before FEES was performed. With FEES, the swallowing capacity of the patient is visualized using an endoscope with video documentation. FEES is suitable for evaluating the late oral and pharyngeal phases of the swallowing process. Experienced (> 10 years) otorhinolaryngologists blinded to the clinical stage and the results of the MDT-PD and the NMS-3 performed the FEES using a 2.6-mm diameter high-definition rhino-laryngovideoscope (ENT-V3, Olympus Medical Systems Corp., Tokyo, Japan). During FEES, the participants were given standardized test boluses in a fixed order. First, one teaspoon of water was administered to test the oral containment; afterward, 90 ml of water was given with the aid of a straw. The patient was asked to drink the water quickly but not as fast as possible. Subsequently, the participant ate one biscuit (Ø 91 mm, weight 20 g) and a slice of bread with butter (~94 × 90 × 9 mm, weight 28 g). The patient sample and the applied FEES technique have been described in detail in a previous publication [1]. The severity of the penetration or aspiration was graded according to Rosenbek's penetration-aspiration scale (PAS) [13]. In penetration (PAS 3–5), the bolus remains inside the larynx and above the vocal folds after swallowing. In the case of aspiration (PAS 6–8), the material reaches beneath the vocal folds.

Table 1
Characteristics of the Parkinson's disease patients.

	PD patients (n = 119)
Age (years)	68.9 ± 10.1
Men	80 (67%)
History of potential aspiration signs *	28 (24%)
History of pneumonia	2 (2%)
BMI	25.5 ± 4.0
MoCA	21.9 ± 4.8
Any cognitive deficit (MoCA < 26 points)	85 (71%)
BDI-II (sum score)	10.6 ± 8.9
No depression (0 − 13)	91 (76%)
Mild depression (14–19)	12 (10%)
Moderate depression (20–28)	8 (7%)
Severe depression (29–63)	8 (7%)
Disease duration (years)	9.7 ± 7.1
H&Y stage 1	5 (4%)
H&Y stage 2	58 (49%)
H&Y stage 3	32 (27%)
H&Y stage 4	20 (17%)
H&Y stage 5	4 (3%)
Total MDS-UPDRS (I-IV) score	58.8 ± 28.4
MDS-UPDRS III score	31.3 ± 14.4
NMS, yes answers	9.8 ± 5.0
DBS	28 (24%)
LED (mg)	752 ± 419

BMI: body mass index; MoCA: Montreal cognitive assessment; BDI-II: Beck depression inventory second edition; H&Y: Hoehn and Yahr; MDS-UPDRS: movement disorder society sponsored revision of the Unified Parkinson's disease rating scale; NMS: nonmotor symptoms questionnaire; DBS: deep brain stimulation; LED: levodopa equivalency dose according to Tomlinson et al. [42]. Values are the mean ± SD unless otherwise indicated.
* Definition: Coughing or clearing one's throat at or shortly after eating or drinking.

To compare the sensitivity and specificity of NMS-3 and MDT-PD, and investigate whether a swallowing-related question could help detect FEES-proven aspiration, we assessed self-reported dysphagia by applying both the MDT-PD and the NMS-3.

The MDT-PD has been designed as a patient self-reported screening tool to identify the clinical presence of dysphagia and to classify the individual risk for aspiration in PD patients. It is subdivided into four sections and consists of 26 questions of which three are dichotomous and 23 have four possible answers:

I. Difficulty swallowing food and liquids (10 items)
II. Difficulty swallowing independent of food intake, including saliva management and pill intake (4 items)
III. Further swallowing-specific and accompanying burdens such as negative influences on the daily routine (9 items)
IV. Swallowing-specific health questions (3 items)

With using a web application, a weighted MDT-PD sum score was returned, which was converted into three categories: (1) no noticeable dysphagia, (2) noticeable oropharyngeal dysphagia, and (3) dysphagia with aspiration risk. The weighted MDT-PD sum score was calculated from the 26 questions of the questionnaire applying binary logistic regression for weighting the variables. All 26 answers were needed for the calculation to receive the score. The cut-offs were 3.65 for allocation to noticeable oropharyngeal dysphagia and 4.79 for allocation to dysphagia with aspiration risk [11]. The questionnaire generally took about 10 min to complete; additional time was necessary for calculating the score. In our study, we shortened the categories naming into (1) no dysphagia, (2) dysphagia, and (3) at risk for aspiration.

Based on the FEES results patients were classified into the following three PAS groups to compare them with the three MDT-PD groups: (1) without severe pathological findings (PAS 1–2), (2) penetration (PAS 3–5), and (3) aspiration (PAS 6–8). We used the PAS score of water to build the three groups because water consistently had the highest score in each patient. Patients with a maximum PAS score of 3–5 (penetration, n = 8) were excluded from calculations for sensitivity, specificity, area under the curve (AUC), positive predictive value, and negative predictive value as their allocation (true positive, false positive, true negative or true false) remained disputable. For example, a positive screening result for a patient with penetration could be interpreted as both a false positive (as there was no aspiration, which was the primary aim of screening) and a true positive (due to existent penetration).

The dichotomous NMS-3 asking about "difficulty swallowing food

Table 2
Results of MDT-PD and NMS-3 compared to endoscopic results.

FEES	MDT-PD			NMS-3	
	No dysphagia	Dysphagia	At risk for aspiration	No subjective dysphagia	Subjective dysphagia
PAS 1–2: without severe path. findings (81 patients)	47	16	18	65	16
	TNa = 63		FPa = 18	TN' = 65	FP' = 16
	TNd = 47		FPd = 34		
PAS 3–5: penetration (8 patients)	4	1	3	7	1
PAS 6–8: aspiration (30 patients)	15	4	11	15	15
	FNa = 19		TPa = 11	FN' = 15	TP' = 15
	FNd = 15		TPd = 15		
Σ = 119	Σ = 66	Σ = 21	Σ = 32	Σ = 87	Σ = 32

TNa: true negative for MDT-PD at risk for aspiration; TNd: true negative for MDT-PD dysphagia; FPa: false positive for MDT-PD at risk for aspiration, FPd: false positive for MDT-PD dysphagia; FNa: false negative for MDT-PD at risk for aspiration; FNd: false negative for MDT-PD dysphagia; TPa: true positive for MDT-PD at risk for aspiration; TPd: true positive for MDT-PD dysphagia; TN': true negative for NMS-3; FP': false positive for NMS-3; FN': false negative for NMS-3; TP': true positive for NMS-3.

or drink or problems with choking within the last month" led to the classification of two subgroups: (1) subjective dysphagia and (2) no subjective dysphagia. This evaluation took less than 1 min. The questionnaires were preferentially completed by the patients on their own. In cases of advanced cognitive or motor impairments, the patients were assisted by their caregivers. Subsequently, objective swallowing results of the FEES investigation were compared with the results of the MDT-PD and NMS-3.

Statistical analyses were carried out with the statistical software package SPSS, version 23 (IBM, USA). Clopper-Pearson confidence intervals were calculated for sensitivity and specificity. Confidence intervals for the predictive values are standard logit confidence intervals according to Mercaldo [14].

3. Results

Penetration and aspiration were frequently found in this cohort. According to the FEES findings, 81 patients were classified as "without severe pathological findings" (PAS 1–2), 8 were grouped into "penetration" (PAS 3–5), and 30 patients into "aspiration" (PAS 6–8). The results are shown in Table 2.

Using established dysphagia diagnostics and classification, 38 of the 119 patients demonstrated relevant penetration, most of them (30/38) even with aspiration. Ideally, these 30 patients who needed further swallowing diagnostics should have been detected by the MDT-PD and NMS-3. However, a high number of false positive results would lead to unnecessary examinations, consequently burdening the patient and the system's limited resources. On the other hand, patients are being endangered by false negative results and the late detection of the presence of aspiration.

3.1. Results based on the MDT-PD

Looking at the results of the MDT-PD, 50% of all patients (19/38) who had been found in FEES with "penetration" or "aspiration" (PAS 3–5 respectively PAS 6–8) were grouped as "no dysphagia" by MDT-PD and, therefore, presented as a false negative result. Of note, 50% (15/30) of the patients with aspiration would not have received a further endoscopic examination based on the MDT-PD result.

On the other hand, of the 81 patients with no severe pathological findings in FEES, 20% (16/81) were classified as having dysphagia and 22% (18/81) as being at risk for aspiration, according to the MDT-PD results.

In summary, 42% (34/81) of the MDT-PD results had to be considered as being false positive, suggesting clinically-relevant problems with swallowing with, in fact, no objective penetration or aspiration.

3.2. Results based on the NMS-3

Similar significant discrepancies were found when comparing the objective swallowing findings of FEES with the results of the NMS-3. An evaluation of the questionnaire revealed that 58% (22/38) of the patients found with "penetration" or "aspiration" on FEES were grouped as "no subjective dysphagia" by NMS-3 and, therefore, classified as false negative. Of them, 39% (15/38) demonstrated aspiration.

On the other hand, 20% (16/81) of the patients were classified as false positive although they showed an inconspicuous FEES.

Both tools (MDT-PD "at risk for aspiration" versus NMS-3) showed similarly low proportions of correctly screened patients (Fig. 1).

The proportion of false positive patients with the MDT-PD (42% or 34/81) was higher than with the NMS-3 (20% or 16/81).

If one assumes in the MDT-PD that all patients with a classification of "dysphagia" or "at risk for aspiration" are in need of further diagnostics, almost half of the patients (53/119) would require a FEES examination. However, this still would only detect half of the patients with aspiration, which does not result in a relevant improvement compared to deciding randomly.

Overall (Table 3), a positive predictive value to detect penetration or aspiration was worse in the MDT-PD than the NMS-3 (31% vs. 48%). The area under the curve (AUC) was not significant for either variation of the MDT-PD and was also poor for NMS-3 (0.65).

4. Discussion

This prospective study reveals a low sensitivity of the MDT-PD for detecting clinically-relevant aspiration in PD patients, resulting in an unsatisfying predictive value for objective (FEES-proven) aspiration. On

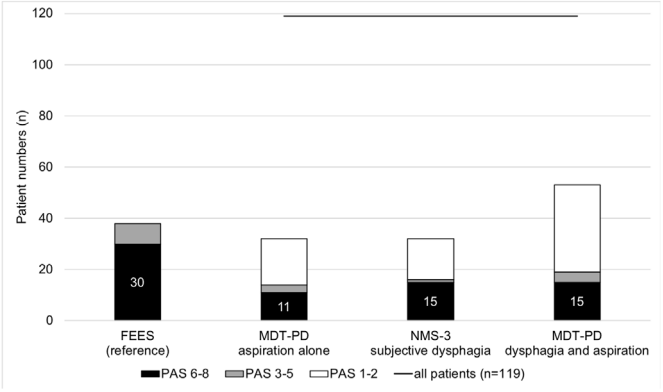

Fig. 1. FEES results grouped as suspicious in the MDT-PD ("dysphagia" + "at risk for aspiration") and NMS- 3 ("subjective dysphagia") screening tools.

Table 3
Sensitivity, specificity, and predictive values for the detection of aspiration with the MDT-PD, as well as detection of penetration or aspiration with MDT-PD and NMS-3.

Questionnaire	Sensitivity	Specificity	Positive predictive value	Negative predictivevalue	AUC
MDT-PD-at risk for aspiration	TPa/(TPa + FNa) = **0.37** (95% CI 0.20–0.56)	TNa/(FPa + TNa) = **0.78** (95% CI 0.67–0.86)	TPa/(TPa + FPa) = **0.38** (95% CI 0.25–0.53)	TNa/(FNa + TNa) = **0.77** (95% CI 0.71–0.82)	**0.57** (95% CI 0.45–0.70, p = 0.24)
MDT-PD-dysphagia	TPd/(TPd + FNd) = **0.50** (95% CI 0.31–0.69)	TNd/(FPd + TNd) = **0.58** (95% CI 0.47–0.69)	TPd/(TPd + FPd) = **0.31** (95% CI 0.22–0.41)	TNd/(FNd + TNd) = **0.76** (95% CI 0.68–0.82)	**0.54** (95% CI 0.42–0.66, p = 0.52)
NMS-3-subjective dysphagia	TP'/(TP' + FN') = **0.50** (95% CI 0.31–0.69)	TN'/(FP' + TN') = **0.80** (95% CI 0.70–0.88)	TP'/(TP' + FP') = **0.48** (95% CI 0.35–0.62)	TN'/(FN' + TN') = **0.81** (95% CI 0.75–0.86)	**0.65** (95% CI 0.53–0.77, p = 0.02)

AUC: area under the curve; CI: confidence interval; TNa: true negative for MDT-PD at risk for aspiration; TNd: true negative for MDT-PD dysphagia; FPa: false positive for MDT-PD at risk for aspiration; FPd: false positive for MDT-PD dysphagia; FNa: false negative for MDT-PD at risk for aspiration; FNd: false negative for MDT-PD dysphagia; TPa: true positive for MDT-PD at risk for aspiration; TPd: true positive for MDT-PD dysphagia; TN': true negative for NMS-3; FP': false positive for NMS-3; FN': false negative for NMS-3; TP': true positive for NMS-3.

the other hand, MDT-PD (at risk for aspiration) and NMS-3 yield a high specificity of 78% respectively 80%, i.e. a low type I error rate, which is equivalent to a low false positive rate. In clinical terms, while unnecessary FEES examinations might be avoided, this can indeed not compensate for low sensitivity, especially when considering the low complication rate of FEES. However, lowering the cut-off of MDT-PD, i.e. applying MDT-PD (dysphagia), an increment of sensitivity (+13%) is accompanied by a relevant loss of specificity (−20%). This reflects a rather undesirable trade-off. Our data support the need for more exploration into effective screening tools, clinical best practice guidelines specific to dysphagia in PD, and understanding optimal predictors of dysphagia in PD. Our patient cohort reflects "real-life" outpatients without preselection due to subjective swallowing problems and, therefore, appears to be well suited to evaluate whether the MDT-PD and the NMS-3 can detect patients with penetration or aspiration.

We applied the FEES technique, which is one gold standard tool to assess dysphagia with aspiration. Therefore, the results were expected to be adequate for proving specificity and sensitivity of the MDT-PD and for detecting clinically-relevant aspiration. In the original study [11], the authors did not report the FEES findings of the patients who were at risk for aspiration. Therefore, it remains unclear how many of those patients suffered from aspiration. Instead, Simons et al., 2014 applied 18 diagnostic criteria, with five degrees of severity each, to categorize patients into three groups: (1) no dysphagia, (2) dysphagia, and (3) at risk for aspiration. Four of them based on clinical assessment tests—-such as the swallowing of 90 ml water and eating bread or a cookie. Two clinical pathological findings resulted in classifying a patient into the "at risk for aspiration" group independent of the FEES result. However, it is known that clinical swallowing tests are not predictive of FEES-proven aspiration [15–17]. In contrast to Simons et al., 2014, we categorized dysphagia in all patients by considering the FEES results, which may be one reason for the different results.

Furthermore, Simons et al., 2014 applied a sum score calculated from 26 questions (variables) and applied binary logistic regression. This might be problematic because this statistical approach needs a minimum number of observed events with at least four events per variable, as suggested by Vittinghoff et al. [18]. For a conservative approach, even ten events per variable have been recommended [19]. Regarding the 26 questions of the MDT-PD, a minimum of 104 events is necessary. Because only 77 patients underwent FEES, this basic requirement would not have been fulfilled even if FEES results would have been reported. The authors themselves critically discussed that the number of cases per variable was small [11].

When comparing the results of the MDT-PD with NMS-3, neither tool managed to reliably detect patients with aspiration (PAS 6–8) nor reduce the number of further examinations in patients with unremarkable findings.

This is in accordance with further studies showing that subjective measures are generally limited for dysphagia diagnostic in PD patients [2]. This observation includes patient self-reported tools and questionnaires as well as clinical swallowing assessments.

One aspect is the impaired self-perception of PD patients. Other studies describe a general lack of self-perception and a high rate of non-declaration of nonmotor symptoms such as speech volume or drooling in PD patients [20,21]. In line with the results of the present study, other authors found that dysphagia is often not or only insufficiently perceived in PD patients, as well [2,22]. Another reason, why subjective assessments fail in case of aspiration might be the large proportion of silent aspirations [1]. This might be caused by reduced coughing, which is known to occur early in PD and to further worsen during the course of disease [5]. Impairment of cough behavior in PD has recently become of more clinical research interest [4] and some authors described impairment of various components of coughing in PD patients [5,23,24]. Higher reflex cough thresholds and a reduced urge to cough can lead to silent aspiration and less perception of dysphagia as well as impaired laryngeal clearance.

It has to be discussed whether different patient characteristics in the original study [11] compared to ours might explain why the MDT-PD had unsatisfactory performance in our setting. The patient characteristics in our study were comparable to those of the original MDT-PD study regarding mean age (68.9 vs.70.9 years), proportion of males (67% vs. 56%), motor score (UPDRS III 31.1 vs. 29.0 points), disease duration (9.7 vs. 11.0 years), and cognition (MoCA 21.9 ± 4.8 vs. 23 ± 5.8 points), indicating no significant differences between the investigated cohorts.

According to the manual, the MDT-PD should not be applied in severely cognitively impaired patients [25]. The mean MoCA values indicate that the patients in both studies had on average mild cognitive impairment, which has to be assumed to be below a cut-off of 26 points [26]. Although the MoCA is not adequate for categorizing the severity levels of dementia [27–31], more pronounced dementia is likely in patients with MoCA values below 14/30 points [27]. This affected only 5/119 (4.2%) of our patients where the reply to MDT-PD questions might have been unreliable. Simons et al., 2014 reported MoCA values for their patients ranging from 2 to 30 points, the mini-mental state examination (MMSE) values from 19 to 30, and Parkinson neuropsychometric dementia assessment (PANDA) values from 13 to 19 points, indicating that they had included more cognitively impaired patients. Besides the aspects of reliability for completing the MDT-PD, this is noteworthy because cognitively impaired PD patients have a higher risk for dysphagia [32].

A limitation of our study is, that we did not conduct intra-rater judgments on PAS scores. Several studies reported that inter-rater and intra-rater reliability of FEES using the PAS or for detecting residues were high [33–36] and we could show in an earlier study, that even the reliability of our own judgments were “almost perfect” [37]. Therefore, we suspect no relevant impact on this study's results.

Particularly in terms of sensitivity, the results of our study are restricted by wide confidence intervals (Table 3), i.e. the precision and therefore the power of our study is rather low. There is no consensus about the margin of error (i.e. half of the confidence interval) in medical science, but in social science 0.05 is frequently used. Applying a maximum margin of error of 0.05 to our postulated sensitivity scores, sample size calculation results in a minimum number of patients with aspiration (PAS 6–8) of 357 (for MDT-PD–at risk for aspiration) respectively 385 (for MDT-PD-dysphagia and NMS-3). Thus, at least a 12-fold increase in sample size would be needed. Nevertheless, even the upper ends of our confidence intervals still represent low sensitivity scores of 56% respectively 69%.

The data in the presented study suggest that the results of the MDT-PD should be interpreted with caution in daily practice. The validity of the MDT-PD has been found to be unsatisfactory, independent of the cognitive status of the patients. Sensitivity and predictive value to detect FEES-proven aspiration were similarly low in both MDT-PD and NMS-3. However, other screening tools for dysphagia in PD are missing. The Swallowing Disturbance Questionnaire [38] is validated for PD and uses English, but has been criticized later for its insufficient validation [39]. Therefore, there is a clear need for more exploration into effective screening tools, clinical best practice guidelines specific to dysphagia in PD, and a better understanding of the optimal predictors of dysphagia in PD. This will help to increase the detection rate of patients with an aspiration risk while avoiding unnecessary consecutive invasive examinations, such as FEES or videofluoroscopy for the quantitation of dysphagia [40,41].

In conclusion, there is still a lack of reliable screening tools for the detection of dysphagia with aspiration in PD patients. The MDT-PD and the NMS-3 should always be interpreted with caution and in the context of the medical history of the patient, considering clinical signs such as coughing while eating or drinking, history of pneumonia, and global clinical impression. However, because these clinical signs are often lacking despite an existing aspiration risk, FEES is recommended in cases of doubt and in the early disease course, as well as in patients with an advanced disease stage. Re-adjustment of the MDT-PD based on FEES results, further studies on the SDQ as a promising tool according to the original validation study, and/or development and validation of a new clinical screening tool with better predictive values for critical dysphagia in PD patients are suggested.

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