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Early Identification and Treatment of Communication and Swallowing Deficits in Parkinson Disease

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Abstract

Parkinson disease (PD) is a complex, progressive, neurodegenerative disorder that leads to a wide range of deficits including fine and gross sensorimotor impairment, autonomic dysfunction, mood disorders, and cognitive decline. Traditionally, the focus for diagnosis and treatment has been on sensorimotor impairment related to dopamine depletion. It is now widely recognized, however, that PD-related pathology affects multiple central nervous system neurotransmitters and pathways. Communication and swallowing functions can be impaired even in the early stages, significantly affecting health and quality of life. The purpose of this article is to review the literature on early intervention for communication and swallowing impairment in PD. Overarching themes were that (1) studies and interpretation of data from studies in early PD are limited; (2) best therapy practices have not been established, in part due to the heterogeneous nature of PD; and (3) as communication and swallowing problems are pervasive in PD, further treatment research is essential.

Keywords

Parkinson disease; communication; swallowing; dysphagia; dysarthria

Parkinson disease (PD) is a neurodegenerative disease that affects ~1 to 2% of the world's population.¹ The pathology of PD is extraordinarily complex, and the molecular mechanisms leading to the phenotypic expression of PD are not well understood. PD involves widespread neuronal cell death from the brain stem to the cerebral cortex, with corresponding loss of function in multiple domains, including sensorimotor control, balance, gait, autonomic function, mood, cognition, communication, and swallowing. The hallmark pathology of PD is death of dopamine neurons that have cell bodies in substantia nigra and project to the striatum.² Substantial degeneration of dopamine neurons is associated with the emergence of the classic signs of the disease—tremor, postural instability, and bradykinesia

—which typically prompts the patient to visit a neurologist. In the prodromal, or preclinical, stages of PD, there are multiple degenerative processes occurring beyond nigrostriatal dopamine depletion, and closer examination can reveal subtle neurological signs.^{3,4} These subtle signs include autonomic dysfunction, anosmia, and mood changes, and also changes in communication and swallowing that often are either missed or attributed to other processes such as aging. When these subtle early signs are missed, the opportunity for early diagnosis, and consequently early intervention, is lost.

Staging is often difficult, as there are many phenotypic expressions of idiopathic PD (i.e., PD without a known cause). Idiopathic PD phenotypes include young onset, akinetic predominant, and tremor predominant, and are each associated with a unique progression and set of associated signs and symptoms.^{5,6} In addition to idiopathic PD, there are multiple inherited forms of PD,^{7,8} which also can present with unique signs, symptoms, and disease course. PD also can vary in age of onset, course, and co-occurring medical comorbidities. Because of this heterogeneity and the widespread pathology of PD, we do not fully understand the onset, progression, or underlying etiology of most deficits, including communication and swallowing deficits. The heterogeneous presentation of PD, like the often-overlooked early signs, limits early diagnosis and treatment. In fact, 90% of individuals with PD have disordered speech and voice that significantly impacts social interactions and quality of life, yet only 3 to 4 % are treated with therapy.^{9–11} It is no surprise that there have been few studies of treatment in early PD.

EARLY STAGE DEFICITS IN COMMUNICATION AND SWALLOWING

Communication and swallowing deficits emerge in the early stages of PD and can become significantly debilitating in later stages of the disease. Results of initial studies suggested that voice, speech, and swallowing difficulties occurred late in the progression of PD.^{12,13} These studies were limited, however, because they relied on patient reports of symptoms, and it is well known that patients' perceptions of their own voice, speech, and swallowing are not always accurate and thus may not be a sensitive measure of early changes for either research or clinical evaluation.^{14–19} In contrast to self-report studies, studies using objective measures indicate that 40 to 78% of patients with early stage PD have changes in voice, speech, and swallowing.^{14,19,20} Thus, despite early reports that voice and swallowing defects do not manifest until later stages of the disease, objective analysis methods have revealed voice and swallowing changes in the early stages of PD, even prior to diagnosis. There is a need for further research to characterize the exact onset, nature, and underlying neuropathology of these changes.

EARLY STAGE VOICE PROBLEMS

Evaluation of voice in individuals with early stage PD has revealed signs of dysfunction such as vocal roughness, breathiness, reduced loudness, reduced vocal range, monopitch, and mild vocal tremor within 5 years of initial diagnosis,²¹ with untreated patients,²² and even as early as 5 years prior to diagnosis.^{23,24} These changes have been confirmed using objective, acoustic measures such as jitter, shimmer, and harmonics-to-noise ratio.^{20,25}

Researchers have reported mixed results for other acoustic measures, such as voice onset time, pause duration, vowel articulation, and diadochokinetic tasks.

EARLY STAGE LANGUAGE DEFICITS

The complexity of PD-related pathology combined with the interrelations among language, speech, and cognitive processes make it difficult to completely separate these three domains. Thus, readers should consider the following sections with the caveat that we need more research to fully understand function and dysfunction in each domain.

Most research on language deficits in PD has focused on deficits related to executive functions (EFs) rather than formal aspects of language, as language deficits are thought to reflect impairments to frontostriatal circuits and thus impairments in EFs. EFs-related communication deficits reported in patients with PD include poor error awareness, hesitations at sentence boundaries, and inefficient syntax.²⁶ In one study, patients with PD maintained correct grammar, yet used atypical syntactic structure while on levodopa and used more recursive grammatical structures than closed phrasing.²⁷ Thus, there is some evidence that PD and related medications affect efficiency and organization of verbal production.

Studies of EFs and language often focus on verbal fluency. Verbal fluency typically is operationally defined as number of content words per minute, and differs from speech fluency, which focuses on words or parts of words regardless of content. Ho and colleagues examined verbal fluency rate on and off levodopa and reported an increase in rate while on medication, indicating a role for dopamine in speech production.²⁸ In a study by Kompoliti and colleagues, however, administration of apomorphine, a dopamine agonist, resulted in a decrease in speech rate.²⁹ This discrepancy may be due to the different mechanisms of action of the two drugs, though it seems clear that modulating dopaminergic signaling affects aspects of speech rate. Researchers have examined the organization of words on verbal fluency tasks such as animal naming. In one study, patients in the early stages of PD were less likely than controls to group items semantically, even though participants with PD were on dopamine-modulating medication.³⁰ In one imaging study,³¹ there were differences between PD and control groups in activation of frontostriatal circuits during fluency tasks. In participants with PD, verbal fluency task performance was associated with hyperactivation bilaterally in the dorsolateral prefrontal cortex and caudate, and hypoactivity in the globus pallidus–internal segment, bilaterally. These findings suggested an increase in the use of frontostriatal circuitry in patients with PD, but results must be interpreted with caution as tasks involve both cognitive effort (grouping items semantically) and motor functions (mental representation of movement sequences for production).

The focus on EFs-related aspects of communication is unsurprising, as several studies have revealed EFs impairments in patients with PD, even in the early stages (see review in Zgaljardic et al³²). In one study, patients newly diagnosed with PD, who had never received treatment, had below average scores on the Wisconsin Card Sorting Test.³³ The test requires examinees to identify changing patterns in a deck of cards, and participants with PD took longer to identify pattern switches. As noted earlier, it is difficult to separate cognitive

deficits from motor problems on these tasks, and methods used in most studies conflate these two types of problems. Thus, although there is good evidence that dopamine is related to cognitive function and dysfunction,³² more research is necessary to differentiate motor from cognitive deficits and identify appropriate treatments for these different types of problems, particularly in early PD.

EARLY STAGE SPEECH DEFICITS

Speech rate in words per minute may be comparable to that of control subjects, much like the common gait disturbances in patients with PD, but adults with PD may have more hesitations and words may rush once they begin a phrase.^{34–36} Findings to date should be interpreted with caution, however, as the measurement methods did not clearly differentiate voice onset time (motoric dysfunction) from cognitive–linguistic processes. Thus, we still do not know how cognitive disturbances interface with speech and sensorimotor dysfunction in PD.

EARLY STAGE SWALLOW DEFICITS

Signs of dysphagia in patients with PD include, but are not limited to, delayed oral transit time, festinated tongue movement (tongue pumping), uncontrolled bolus with premature loss to the pharynx, piecemeal deglutition; reduced movement of the hyolaryngeal complex, pharynx, tongue base, and epiglottis; as well as esophageal motility and reflux issues.^{15,16,37–47} Deficits with bolus preparation and transport often lead to residuals in the aerodigestive pathway and ultimately airway compromise.⁴⁸ Consequences of dysphagia in patients with PD may include weight loss, diet change, and death from aspiration pneumonia.^{41,47,49–51} A mean survival time of 24 months after onset of significant dysphagia symptoms has been reported.¹² Further, swallowing difficulty can diminish quality of life.^{37,52} Individuals with PD may not want to dine with friends, family, and work colleagues and are often reluctant to eat in public, due to embarrassment about drooling, slowness of eating, or fear of choking.⁵³ Even subtle changes in swallowing function can have a large psychosocial impact on the patient and the caregiver.³⁷

Several studies have revealed objective swallowing changes in patients with early stage PD. Sung and colleagues used impedance manometry to study newly diagnosed individuals, most of whom had no reported dysphagia, and found robust differences between these adults and age-matched controls in swallowing physiology, including reduced upper esophageal sphincter resting pressure, lower pharyngeal peak pressures, slower pharyngeal transit times, and abnormal esophageal manometry.¹⁹ Swallowing impairments do not correlate well with other measures of disease severity and may go unnoticed by both individuals with PD and their health care providers,¹⁷ particularly in the early stages. It is evident from the profound consequences of dysphagia in patients with PD that early identification and treatment has the potential to reduce the impact of dysphagia and improve quality of life.

TREATMENT OF EARLY STAGE COMMUNICATION AND SWALLOWING DEFICITS

Unfortunately, communication and swallowing deficits are refractory to standard medical therapies such as medications (for a systematic review, please see Baijens and Speyer⁵⁴) and deep brain stimulation,^{55–59} though these deficits do respond to behavioral intervention.^{11,60–62} Optimizing treatment and timing of intervention is a challenge, however, as we do not clearly understand the underlying neural mechanisms contributing to PD-related communication and swallowing deficits, or the time point at which these deficits emerge. Thus, intervention for communication and swallowing deficits is again limited by a lack of evidence on which to base clinical practices.

Given the current evidence (and/or lack thereof), making informed decisions regarding how best to approach and treat communication and swallowing deficits in PD can be problematic. The purpose of this article is to review the literature for treatment of communication and swallowing deficits in the early stages of PD. Our general approach was to search the electronic databases PubMed (1980 to June 2013), Google Scholar (1982 to June 2013), Web of Knowledge (1965 to June 2013), and Cochrane Library (1980 to June 2013). The following keywords were used either alone or in combinations: Parkinson's disease, Parkinson's disorder, Parkinsonism, voice, voice disorder, speech, speech disorder, dysarthria, swallowing, deglutition, dysphagia, and speech therapy. Abstracts were reviewed to identify articles in the English language that reported primary research on intervention for communication or swallowing disorders for individuals with PD. We also retrieved articles from reference lists. We expanded the search to include information about cognitive deficits and drooling, as these are related to communication and swallowing deficits. There were no restrictions on study design. Although we attempted to include only interventions during early stages of PD, these were limited for reasons mentioned above. It was not our intent to provide an in-depth review of study designs, methods, analyses, conclusions, and limitations. Rather, our aim was to provide the reader with an overview of research to date and provide fodder for discussion about how we can improve identification and treatment for early communication and swallowing disorders.

Treatment for Communication Deficits

As shown in Table 1, most published treatments for communication deficits are for sensorimotor problems and include intensive exercise (such as Lee Silverman Voice Treatment or respiratory effort-based therapy), traditional voice or speech therapy, music therapy, drug intervention, and surgical interventions such as deep brain stimulation. Overall, drugs and surgical intervention improvements to speech and voice, functional improvements, or changes to quality of life as it relates to communication.^{22,55–59,63,64} Improvements in speech and voice acoustic measures and intelligibility and negative impacts of communication disorders have been observed with intensive communication-based exercise.^{10,61,65–73} As has been noted previously, many studies are not conducted in the early stages of PD, as individuals are unfortunately diagnosed at mid to later stages of the disease. The general limitations of these studies are discussed below.

Treatment for Swallow Deficits

Akin to our conclusions for communication deficits, there is an overall paucity of clinically relevant research pertaining to dysphagia in patients with PD, especially in the early stages. Pharmacological and surgical treatments appear to have little overall positive effect on swallowing physiology,⁷⁴ especially if the individuals tested were not experiencing a significant dysphagia.⁷⁵ Adapting bolus characteristics such as consistency may change certain parameters of swallowing safety. For example, one study showed that honey-thickened liquids resulted in the fewest aspiration events⁷⁶; however, participants preferred the use of the chin down posture over the use of thickened liquids. Participants' second choice was use of nectar-thick liquids in place of thin liquids.⁷⁶ Patients presented with a higher oral transit time and more tongue pumps when swallowing pudding-thick consistencies, but pudding-thick consistencies resulted in lower penetration/aspiration scores than did thin liquids.³⁹ As such, the use of changing bolus characteristics or implementing postural maneuvers should be based on results of individual swallow studies. Exercise programs, such as expiratory muscle strength training (EMST), have improved cough and swallow function.^{77,78} Individuals that received active EMST presented with improved penetration/aspiration scores, and improved hyolaryngeal function (excursion time and displacement) as compared with both their pretreatment assessment and the sham group.⁷⁸ The authors postulated that the mechanism of decreased penetration and aspiration scores was the increase in hyolaryngeal displacement. Both treatment and sham groups reported improved quality of life posttreatment.⁷⁸ There appears to be very little research examining other types of swallowing-specific exercises as a treatment for PD-related dysphagia. Patient education and biofeedback have also been shown to improve pharyngeal residue and perhaps quality of life.⁷⁹ From these studies, we can conclude that exercise-based therapies and changing bolus characteristics may improve swallowing function, but evidence for this is limited to a few studies (Table 2).

CONCLUSIONS

Despite a lack of double-blind randomized controlled clinical trials, a review of the literature revealed trends for treatment efficacy. Intensive training that targeted underlying physiology (vocal dysfunction, oropharyngeal swallowing) tended to show efficacy in treating those aspects of the dysfunction. Pharmacological and surgical interventions for PD (levodopa, deep brain stimulation) did not reliably improve communication or swallowing deficits. The overarching finding of our review was that few studies focused on communication and swallowing in early stage PD and interpretation of data from those studies was significantly limited. Readers are directed to review articles in which these limitations are discussed in detail.^{6,54,62,80} Due to the heterogeneous nature of PD and the lack of identification of individuals with PD in the early stages, best therapy practices have not been established. Communication and swallowing complications are pervasive in PD, however, and there is a need for well-designed research to address best therapy practices. We conclude that interventions for PD should be based on a better understanding of the underlying neuropathology and a deeper and wider evidence base.

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Learning Outcomes

As a result of this activity, the reader will be able to (1) Describe the associated signs/symptoms of voice, speech, and language issues related to early PD; (2) explain how medications and surgical interventions are often unsuccessful at treating communication and swallowing disorders; (3) identify literature that addresses early communication and swallowing deficits in PD.

Table 1

Summary of Literature for Treatment of Communication Deficits

Type	Premise	Citation	Participants	Control	Intervention	Outcome Measures	Summarized Outcomes
Review	LSVT	Ramig and Verdolini, 1998 ⁶⁵	NA	NA	NA	NA	LSVT improves communication in addition to voice and speech improvements.
Review	LSVT	Trail et al, 2005 ¹⁰	NA	NA	NA	NA	Eighty-six percent of PD patients had abnormal voice that occurred early. LSVT increases SPL. DBS occasionally had a worsening effect on perceptual assessment of speech.
Review	LSVT	Herd et al, 2012 ⁶⁶	159 participants from 6 studies	NA	LSVT LOUD, LSVT-ARTIC, RT, two delivery methods for LSVT, ear device giving altered auditory device feedback and traditional rate reduction behavioral therapy	Rating scales for intelligibility and dysarthria; objective and subjective acoustic measures of speech and laryngeal activity; level of communication participation; ADL; QOL; and depression	No SLT is more efficient than another.
Review	Medication	Schulz and Grant, 2000 ⁶³	NA	NA	NA	NA	Optimally medicating patients is the indicated treatment for voice and speech function.
Review	Exercise	Konerth and Childers, 2013 ⁸¹	Age > 40, H&Y stage = I–III, UPDRS < 50	NA	NA	NA	There is a positive impact of exercise on verbal fluency, but long-term impact of exercise on PD is unknown.
Report	Acoustic measures	Rusz et al, 2011 ²⁰	46 participants: PD 19 M, 4 F, ave age = 61.74, H&Y stage 1–2, 23 NI (16M, 7F) ave age = 58.08	Aged matched controls	NA	Phonation, articulation, and prosody	Seventy-eight percent of early untreated patients with PD show some degree of vocal impairment.
Report	Voice physiology	Holmes et al, 2000 ²¹	60 participants: early PD 15 M, 15 F, ave age = 68.4, ave Webster = 8.83; late PD 15 M, 15 F, ave age = 74.5, ave Webster = 18.3	Early versus late	Observation	Levels of pitch, loudness, variability, breathiness, harshness, and tremor	Some features did not deteriorate with disease progression, (harshness, etc.) but some did (breathiness, monopitch, etc.).
Report	Voice physiology	Harel et al, 2004 ²³	Within-subject (<i>n</i> = 1)	Within-subject	Observation	F ₀	There is a decrease in F ₀ that is observable 5 y before clinical diagnosis.

Type	Premise	Citation	Participants	Control	Intervention	Outcome Measures	Summarized Outcomes
Treatment	VRT versus RT	Smith et al, 1995 ⁸²	22 participants: PD VRT 13, RT 9, ages = 49–76 (overall), ave H&Y stage 3 (overall)	Treatment group	VRT versus RT	Glottal phonatory configuration, glottal incompetence, supraglottal function under various conditions	VR improved laryngeal adduction.
Treatment	LSVT versus RT	Ramig et al, 1996 ⁶⁷	35 participants: LSVT 22, ave age = 63.23, TSD = 6.55 y; RT 13, ave age = 65.31, TSD = 4.77 y	Treatment group	LSVT and RT	Vocal intensity	LSVT maintains or improves vocal intensity after treatment. Both LSVT and RT groups showed deterioration of intensity over 12 mo but LSVT group did not deteriorate below pretreatment levels.
Treatment	LSVT versus RET	Baumgartner et al, 2001 ⁶⁸	20 participants: LSVT 11 M, 2 F, ave age = 66.7, ave H&Y stage 3.1; RET 5 M, 2 F, ave age = 64.8, ave H&Y stage 2.6	Treatment group	LSVT and RET	Extent of breathiness or hoarseness	LSVT resulted in significant reduction in hoarseness and breathiness.
Treatment	LSVT versus RET	Ramig et al, 2001 ⁶⁹	33 participants: LSVT 17 M, 4 F, ave age = 61.3, UPDRS score = 27.7; RET 7 M, 5 F, ave age = 63.3, UPDRS = 12.9	Treatment group	LSVT and RET	SPL and STSD	LSVT changes likely to be maintained up to 2 y after end of treatment.
Treatment	LSVT	Ramig et al, 2001 ⁶¹	43 participants: LSVT 7 M, 7 F, ave age = 67.9, TSD = 8.6; PD NT 7 M, 8 F, ave age = 71.2, TSD = 7.8; NI NT 7 M, 7 F, ave age = 69.8	Treatment and control group	LSVT	SPL	LSVT produces higher SPL for sustained /a/, rainbow passage, monologue, and picture description after treatment.
Treatment	LSVT	Sapir et al, 2007 ⁶⁰	43 participants: LSVT 7 M, 7 F, ave age = 68, ave H&Y = 1.33; NT (8 M, 7 F, ave age = 77.6, ave H&Y stage = 1.86); NT, NI (14)	Treatment and age-matched controls	LSVT	Measurements of VocSPL, vowel formants /i/, /u/, and /a/ and vowel goodness /i/, /u/, and /a/	LSVT improved VocSPL, f_2 of the vowel /u/ (f_2u), and the ratio f_3/f_2u in PD patients, which were the only main differences between PD and healthy individuals. These ratings improved with LSVT.
Treatment	Group LSVT	Searl et al, 2011 ⁷¹	15 participants: 9 M, 6 F, ave age = 70.4, ave UPDRS score = 1.5	None	Group LSVT	Vocal intensity, Fo mean, standard deviation and range, maximum phonation time, listener judgment of loudness	LSVT increases voice intensity, Fo maximum, and Fo range in group setting.
Treatment	LSVT	Narayana et al, 2010 ⁷²	10 participants: 8 M, 2 F, ave age =	NA	LSVT LOUD	SPL	Bilateral activations were still present in SMA, PMd, visual

Type	Premise	Citation	Participants	Control	Intervention	Outcome Measures	Summarized Outcomes
Treatment	Group music therapy	Elefant et al, 2012 ⁸³	60, ave UPDRS = 51 60, ave UPDRS = 51 10 participants: 7 M, 3 F, ages 55–84, H&Y stage 2–3	None	Weekly musical therapy ⁸³	Fluency, mean Fo, Fo standard deviation, singing accuracy	areas, cerebellum, superior and middle temporal gyri. ⁷² LSVT increases SPL. Increase in singing quality. No decline in speaking quality and only slight speech improvements were noted.
Treatment	LSVT	Cannito et al, 2012 ⁷³	8 participants: 5 M, 3 F, ave age = 66.30, TSD = 11.375	None	LSVT measured 3 d before and after treatment	Intelligibility, intensity	LSVT improved sentence intelligibility in most participants and increased vocal loudness in those that did not improve intelligibility.
Treatment	Exercise	Cruise et al, 2011 ⁸⁴	28 total: PD exercise (15); PD nonexercise (13), H&Y stage = 1–3	Nonexercise	Combination of strength and cardiovascular training	QOL assessment with communication component	Exercise has no negative impact on an outcome measure but positive on verbal fluency.
Treatment	Music therapy on PD voice	Haneishi, 2001 ⁸⁵	4 PD total: 4F	Pre- and posttreatment	MTVP	Speech intelligibility, vocal intensity, Fo, Fo variability, maximum vocal range, maximum duration of sustained vowel phonation	MTVP increases in speech intelligibility and vocal intensity.
Treatment	Voice rehabilitation	de Angelis et al, 1997 ⁸⁶	20 PD total: 17 M, 3 F, ave age = 62.9, H&Y stage 1–5	Pre- and posttreatment	Resonant voice therapy	Maximum phonation times, decreased s/z ratio, air flow	Group voice rehabilitation increased maximal phonation, decreased air flow, and increased vocal intensity. Possible increased laryngeal efficiency was observed.
Treatment	Deprenyl	Stewart et al, 1995 ²²	12 participants: ages 42–73, ave H&Y stage = 1.45, ave ADL score = 93.08	Drug on and off	Deprenyl	13 dimensions used in the Darley et al, 1975, Motor Speech Disorders, Philadelphia, PA: Saunders	Deprenyl did not result in consistent changes in speech in patients with early PD.
Treatment	Apomorphine	Kompoliti et al, 2000 ²⁹	10 participants: 9 M, 1 F, ave age = 73.4, H&Y stage = 2–4 off	Drug on and off	Apomorphine	Laryngeal: maximum sustained vowel phonation, constant vowel phonation; articulatory: speech intelligibility score, speaking rate, efficiency ratio	Laryngeal and articulatory speech elements are not responsive to central dopamine stimulation with apomorphine.
Treatment	Levodopa	Gallena et al, 2001 ⁶⁴	13 participants: PD 5 M, 1 F, ave age = 55.67, H&Y stage 1–3; NI 5 M, 2 F, ave age = 43.6	Drug on and off	Levodopa	Laryngeal EMG recordings, perceptual judgment of “abnormality”	No group differences on laryngeal muscle activity noted. Speech improvements on levodopa were due to reductions in TA muscle activity.

Type	Premise	Citation	Participants	Control	Intervention	Outcome Measures	Summarized Outcomes
Treatment	Levodopa	Rusz et al, 2013 ²⁵	38 participants: PD 16 M, 3 F, ave age = 59.8, H&Y stage = 2.2; NI 16 M, 3 F, ave age = 60.3	Age-matched controls	Levodopa or dopamine agonist	UPDRS and measures of phonation, articulation, and prosody (18 measures)	Reduced speech impairment, specifically loudness of speech, quality of voice, pitch variability and articulation noted after pharmacotherapy.

Abbreviations: ADL, activities of daily living; s/z ratio:ratios between s = maximum expiration time of a voiceless phoneme/z = maximum expiration time of a voiced phoneme; ave, average; TA, thyroarytenoid; DBS, deep brain stimulation; EMG, electromyography; VRT, voice and respiration treatment; F, female; Fo, fundamental frequency; H&Y, Hoehn and Yahr scale; LSVT, Lee Silverman Voice Treatment; M, male; MTVP, music therapy voice protocol for Parkinson's disease; NA, not applicable; NI, neurologically intact; NT, no treatment; RT, respiration therapy; QOL, quality of life; RET, respiratory effort training; SLT, speech language therapy; SPL, sound pressure level; PMd, dorsal premotor cortices; STSD, semitone standard deviation; VocSpl, vocal sound pressure level; TSD, time since diagnosis; UPDRS, Unified Parkinson Disease Rating Scale; t₂ second formant; VRT, vocal and respiratory treatment.

Table 2

Summary of Treatments for Dysphagia

Type of Article	Premise	Citation	Participants	Control	Intervention	Outcome Measures	Summary of Outcomes
Review	Therapy	Speyer et al, 2010 ⁸⁰	Review	NA	Review	Review	Conclusions could not be generalized due to the heterogeneity of the studies included.
Review	Dysphagia	Aminoff et al, 2011 ⁸⁷	Review	NA	Review	Review	Recommends patients kept NPO until assessed by an SLP. Emphasizes importance of education. Recommends the use of PEG tubes early.
Review	Rehabilitation	Smith et al, 2012 ⁸⁸	Review	NA	Review	Review	Despite a paucity of research investigating rehabilitative interventions for dysphagia as compared with compensation of deficits, the reviewers suggest rehabilitation may be more beneficial for individuals with PD.
Review	DBS, drug	Sapir et al, 2008 ¹¹	Review	Review	Review	Review	Authors suggest that although DBS and pharmaceuticals are helpful for gross motor deficits resulting from PD, they may be detrimental, or have mixed results for both swallowing and speech.
Review	All Tx's	Baijens and Speyer, 2009 ⁵⁴	Review	Review	Review	Review	The authors determined that although positive group tendencies may be observed with therapy for dysphagia in PD, no generalized conclusions can be drawn at this time.
Review	Levodopa	Melo and Monteiro, 2013 ⁸⁹	Review	Review	Review	Review	The efficacy of levodopa as a treatment for dysphagia in PD is controversial.
Review	Drugs	Deane et al, 2001 ⁹⁰	Review	Review	Review	Review	Authors found a lack of evidence to either support or refute the use of nonpharmacological therapies for dysphagia in PD.
Physiology	Bolus	Troche et al, 2008 ³⁹	10 participants: 5 M, 5 F, ages 56–77, H&Y stages 2–3; dysphagia confirmed by VFSS	Within-subject design	Thin and pudding-thick consistencies	P/A score, oral transit time, number of tongue pumps, and pharyngeal transit time	Patients had higher oral transit time and more tongue pumps with pudding-thick consistencies. However, these consistencies resulted in lower P/A scores than did thin liquids.

Type of Article	Premise	Citation	Participants	Control	Intervention	Outcome Measures	Summary of Outcomes
Physiology	Bolus	Van Lieshout et al, 2011 ⁹¹	10 participants: 7 M, 3 F, 47–75, H&Y stages 1–3	13 age-matched adults and 15 younger healthy adults	Different liquid consistencies	Amplitude and duration of tongue body and tongue dorsum movements during swallows of thin and honey-thick liquids	Individuals with PD showed smaller and more variable movements in the horizontal movement plane than did the age-matched controls. Rate- and liquid-specific differences existed between participants with early stage PD and healthy controls. Overall tongue control was relatively preserved in the individuals diagnosed with PD.
Treatment	Gum chewing	South et al, 2010 ⁹²	20 participants: 13 M, 7 F, ages 58–75, H&Y stage 2–4, nonsymptomatic for oropharyngeal dysphagia	Within-subject design	Gum chewing	Frequency and latency of swallow	The modification of the sensorimotor input by chewing gum created a statistically significant difference in both frequency and latency of the swallow.
Treatment	Levodopa	Bushmann et al, 1989 ⁹³	20 participants: PD 15 M, 5 F, ages 42–85 (mean = 65.7), H&Y stage 1–4; 13 controls (no effort to recruit individuals with dysphagia), 15 patients, and 1 control with dysphagia	Yes; 13 normal controls; patients' spouses	Levodopa administration	Aspiration before, during, and after the swallow; mastication; bolus formation; stasis; lingual peristalsis; tongue movements; laryngeal elevation and closure; and piecemeal deglutition	Levodopa and improvement in the general PD signs did not reliably indicate swallowing function. Seven of 20 participants presented with improved swallow in the levodopa on condition whereas 1/20 participants presented with a worse swallow in this condition.
Treatment	EMST	Pitts et al, 2009 ⁷⁷	10 participants: 10 M, ages 60–82, H&Y stage 2–3	Within-subject design	EMST	P/A score for thin liquid, maximum expiratory pressure, and airflow during cough	A significant decrease in the P/A scores was found following EMST.
Treatment	EMST	Troche et al, 2010 ⁷⁸	60 participants: 47 M, 13 F, ages 55–85, H&Y stages 2–4; reported some degree of dysphagia	Placebo-control group	EMST	P/A score for thin liquid, maximum expiratory pressure, hyoid movement, and swallowing quality of life measures	EMST associated with improved P/A scores, and improved hyolaryngeal function. Both the treatment and sham groups indicated improved quality of life posttreatment.
Treatment	LSVT	El Sharkawi et al, 2002 ⁴²	8 participants: 6 M, 2 F, ages 48–77, H&Y stage 2–4	None	LSVT	Vocal intensity, fundamental frequency, the patient's perception of speech change, presence of physiological motility disorders of the oropharyngeal swallow including various timing and kinematic measures	Following LSVT therapy, a significant reduction was observed in oral residue (following 3 mL and 5 mL of thin liquid) as well as a decrease in many of the temporal measures (such as oral transit time).

Type of Article	Premise	Citation	Participants	Control	Intervention	Outcome Measures	Summary of Outcomes
Treatment	Maneuver	Felix et al, 2008 ⁹⁴	4 participants: 3 M, 1 F, ages 66–78, H&Y stage 3; reported some degree of dysphagia	Within-subject design	Swallowing with effort maneuver while using a biofeedback device taking measurements of pressure on the outside of the neck	Stasis, voice changes following swallow, coughing or choking after swallow, and pressure on the outside of the neck during swallow	One of four showed functional improvements swallowing liquids and three-quarters with solids posttreatment. Pressure measurements as taken on the outside of the neck were statistically higher posttreatment.
Treatment	Swallow exercise	Nagaya, et al, 2000 ⁹⁵	10 participants: 5 M, 5 F, ages 47–93, H&Y stages 3–4; reported some degree of dysphagia; were taking levodopa	Yes; 12 normal controls; not matched for age or sex	Swallowing training: tongue range of motion exercises, tongue resistance exercises, vocal fold adduction exercises (hold breath with hard glottal attacks), Mendelsohn maneuver, neck range of motion exercises, trunk and shoulder joint range of motion exercises	Aspiration, premotor time (defined as the visual time between the visual cue to swallow and the initiation of the swallow, measured using EMG), stasis (in oral cavity, valleculae, and pyriform sinuses), tongue pumping, bolus control, and piecemeal deglutition	Following training, a significant decrease was observed in the premotor time of the swallow. Additionally, 8/10 participants reported that swallowing was easier following training as compared with before.
Treatment	Swallow exercise	Robertson and Thomson, 1984 ⁹⁶	18 participants: 17 M, 1 F, ages 50–82; long-standing diagnosis of PD	Inclusion of treatment and control groups	Intensive group speech therapy program including: method, capacity, and control of respiration; coordination and control of voice production; range; strength and speed of articulatory muscular movement and articulation; control of rate; variation of intonation; and stress patterns	Reflexes portion of the Dysarthria Profile (Robertson, 1982) ¹⁰¹	The intensive group speech therapy program resulted in improvements in several oromotor reflexes including swallowing as measured by swallow response times for solids and liquids.
Treatment	Education + Tx	Manor et al, 2013 ⁷⁹	42 participants: 24 M, 18 F, ages 60–77, H&Y stages 1–3; reported some degree of dysphagia	Inclusion of VAST and conventional therapy groups	VAST (exposed to videos of the swallowing process as well as their own swallows+ conventional therapy) or conventional therapy (swallowing exercises and compensatory therapy technique)	P/A score, stasis, bolus flow time, quality of life, degree of pleasure from eating, and swallowing disturbances questionnaire	The group of patients who received VAST presented with a significant reduction in pharyngeal residue following therapy. This group also showed a significant improvement in quality of life scores.
Treatment	Bolus + posture	Logemann et al, 2008 ⁷⁶	711 participants: 498 M, 213 F, ages 50–95, H&Y stage 1–5; 228 PD without dementia, 135 PD with dementia	None, internal controls included	Chin-down posture, nectar-thickened liquids, honey-thickened liquids	Aspiration, treatment method preference	Honey-thickened liquids resulted in the least aspiration events. Participants preferred the use of the chin-down posture over the use of thickened liquids.
Treatment	DBS	Lenggerer, et al, 2012 ⁷⁵	18 participants: 11 M, 7 F, ages 49–79, UPDRS Scores 7–58; had received DBS; presented with no clinical	Within-subject design	2 conditions: DBS on and DBS off while swallowing viscous (Jell-o (Kraft Foods Group Inc., Northfield, IL)), fluid (water), and solid (bread) consistencies	P/A score, lingual control, palatal closure, position of bolus at onset of swallow, velopharyngeal closure, pharyngeal contraction/	DBS on showed reduced pharyngeal delay time, decreased pharyngeal transit time, decreased pharyngeal response time, and decreased cricopharyngeal opening.

Type of Article	Premise	Citation	Participants	Control	Intervention	Outcome Measures	Summary of Outcomes
Treatment	DBS	Ciucci et al, 2008 ⁷⁴	14 participants: 12 M, 2 F, ages 50–77, H&Y stages 2–4	Within-subject design signs/symptoms of dysphagia	2 conditions: DBS on and DBS off while swallowing thin liquid and solid consistencies.	bolus propulsion, laryngeal excursion, bolus propulsion through UES, clearance of pyriform sinus residual, UES parameters, and airway reaction	Although DBS of the STN was found to modulate the pharyngeal phase of deglutition in these participants, overall, DBS was found to have no clinically relevant influence on deglutition.
Treatment	Drugs	Hunter et al, 1997 ⁹⁷	15 participants: 12 M, 3 F, ages 54–80; no baseline staging info presented; symptomatic for dysphagia	None, internal controls included	Before and after administration of levodopa and apomorphine using thin liquid, semisolid (jelly), solid (dry toast)	Aspiration, laryngeal penetration, vallecular pooling, location of the bolus during laryngeal elevation, duration of oral prep phase, duration of pharyngeal phase, duration of rapid pharyngeal transit, swallow duration, and number of posterior tongue elevations	Inconsistent results overall. Levodopa resulted in fewer clearing swallows and reduction of the oral preparatory phase but an increase in oral preparatory time and the total initial swallow time. A decrease in the rapid pharyngeal transit time for semisolids and less vallecular pooling were found following apomorphine.
Treatment	NMES + Tx	Heijnen et al, 2012 ⁹⁸	88 participants: 65 M, 23 F, ages 40–80, H&Y stage 1–4; reported some degree of dysphagia	3 treatments included	Group 1—traditional logopedic dysphagia treatment (oromotor exercises, airway protection maneuvers, postural compensation); group 2—same treatment + NMES stimulated at the motor level; group 3—same treatment + NMES on a sensory level (VitalStim; Empi, Inc., St. Paul, MN)	Quality of life and dysphagia severity scale	All three groups showed significant improvement on the dysphagia severity scale and displayed restricted positive effects on quality of life measures. Minimal group differences were observed.
Treatment	NMES	Baijens et al, 2012 ⁹⁹	10 participants: 7 M, 3 F, ages 50–80, H&Y stage 1–3; reported some degree of dysphagia	10 age- and sex-matched normal controls	VitalStim: 3 different electrode positions	Aspiration; moment of opening and closing of the glossopharyngeal junction, laryngeal vestibule, and upper esophageal sphincter; movement of the hyoid bone; and lingual pumping	For most parameters, no statistical significance was found between swallows with NMES and those without.
Treatment	Thermo- tactile Tx	Regan et al, 2010 ¹⁰⁰	15 participants: 7 M, 8 F, ages 60–79, H&Y stage 2–5; presented with	Within-subject design	Thermal tactile stimulation	Oral transit time, pharyngeal transit time, total transit time, and pharyngeal delay time	Thermal tactile stimulation significantly reduced pharyngeal transit time, total transit time, and pharyngeal

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Type of Article	Premise	Citation	Participants	Control	Intervention	Outcome Measures	Summary of Outcomes
			dysphagia as confirmed on VFSS, dysphagia outcome and severity scale: 1–5				
			dysphagia as confirmed on VFSS, dysphagia outcome and severity scale: 1–5				
			dysphagia as confirmed on VFSS, dysphagia outcome and severity scale: 1–5				
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Abbreviations: AD, Alzheimer disease; PEG, percutaneous endoscopic gastrostomy; ave, average; DBS, deep brain stimulation; VFSS, videofluoroscopic swallow study; EMST, expiratory muscle strength training; F, female; H&Y, Hoehn & Yahr scale; LSVT, Lee Silverman Voice Treatment; M, male; NA, not applicable; NMES, neuromuscular electrical stimulation; NPO, nothing by mouth; P/A, penetration/aspiration; PD, Parkinson disease; RT, respiratory training; UES, upper esophageal sphincter; SLP, speech-language pathologist; STN, subthalamic nucleus; Tx, treatment; UPDRS, Unified Parkinson Disease Rating Scale; VAST, video-assisted swallowing therapy.