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Can adjunctive electromyographic biofeedback help maintain long-term prophylactic swallowing therapy results in Parkinson's disease? A pilot study

Biofeedback eletromiográfico como coadjuvante pode ajudar a manter os resultados da terapia profilática de deglutição em longo prazo na doença de Parkinson? Um estudo piloto

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ABSTRACT

Purpose: This pilot study aimed to verify the influence of using EMG biofeedback as an assisting method to maintain long-term results for swallowing therapy in older adults with Parkinson's disease in a prophylactic approach. **Methods:** Subjects were evaluated as to the oral intake level (Functional Oral Intake Scale – FOIS), quality of life (SWAL-QOL questionnaire), and videofluoroscopy of swallowing of solid, pudding and liquid consistencies. The severity of dysphagia was assessed using the Dysphagia Outcome and Severity Scale (DOSS). All procedures were performed before, after three months, and after six months of speech-language therapy treatment for oropharyngeal dysphagia. **Results:** Three subjects were treated with prophylactic speech-language therapy, and three with prophylactic speech-language conventional therapy using adjunctive EMG biofeedback in a total of 18 sessions. Six patients experienced a reduction of the severity of the dysphagia, improved oral intake levels and quality of life after the rehabilitation program. The oral intake level was maintained six months after conventional therapy for two patients and for all participants treated with EMG biofeedback. **Conclusion:** Both therapy modalities with PSLT showed improved quality of life, oral intake level, and reduction of the severity of dysphagia, but the benefits were maintained over time only for participants in the experimental group.

Keywords: Deglutition Disorders; Parkinson disease; Rehabilitation; Therapy; Electromyography

RESUMO

Objetivo: Este estudo piloto teve como objetivo verificar a influência do uso do biofeedback EMG como método coadjuvante para auxiliar na manutenção dos resultados a longo prazo da terapia da deglutição em idosos com doença de Parkinson em uma abordagem profilática. **Métodos:** Os sujeitos foram avaliados quanto ao nível de ingestão oral (Functional Oral Intake Scale - FOIS), qualidade de vida (questionário SWAL-QOL) e videofluoroscopia da deglutição das consistências sólida, pudim e líquida. A gravidade da disfagia foi avaliada por meio do Dysphagia Outcome and Severity Scale (DOSS). Todos os procedimentos foram realizados antes, após três meses e após seis meses do tratamento fonoaudiológico para disfagia orofaríngea. **Resultados:** Três sujeitos foram tratados com terapia fonoaudiológica profilática e três com terapia convencional fonoaudiológica profilática utilizando biofeedback EMG coadjuvante em um total de 18 sessões. Seis pacientes apresentaram melhora nos níveis de ingestão oral, gravidade da disfagia e qualidade de vida após o programa de reabilitação. O nível de ingestão oral foi mantido seis meses após a terapia convencional para dois pacientes e todos os participantes tratados com biofeedback EMG. **Conclusão:** Ambas as modalidades de terapia *profilática* mostraram melhora na qualidade de vida, nível de ingestão oral e gravidade da disfagia, mas os benefícios foram mantidos ao longo do tempo apenas para os participantes do grupo experimental.

Palavras-chave: Transtornos de deglutição; Doença de Parkinson; Reabilitação; Terapia; Eletromiografia

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INTRODUCTION

Parkinson's disease (PD) is a chronic, progressive, degenerative disease caused by a reduction in dopamine production, and aging is a risk factor[1]. Dysphagia is also one of PD's main manifestations, commonly related to ineffective mastication[2], impaired tongue function[3], reduced elevation and excursion of the hyolaryngeal complex[4], altered esophageal swallowing[5], and incoordination between breathing and swallowing[6]. Untreated, dysphagia may impair the nutritional status[7] and quality of life[8] and even lead to death in more severe cases due to the high risk of aspiration[9].

The signs and symptoms of dysphagia occur in the later stages of the disease[10]; however, a preventive, therapeutic approach may avoid the consequences of its evolution. Although studies with prophylactic approaches are scarce in neurogenic diseases, they have been frequently addressed in head and neck cancer cases to avoid the physiological changes in swallowing that occur due to radiotherapy processes, with favorable results for the swallowing function[11,12].

Concerning the strategies for rehabilitating the swallowing function in PD, speech-language therapy has presented effective results to reduce the signs and symptoms of dysphagia. It includes oral motor exercises, expiratory muscle strength training, postural techniques, Lee Silverman voice treatment, and postural compensation and airway protection maneuvers[13]. Currently, speech-language therapists are mainly concerned about making sure they can maintain long-term therapy results since PD is a degenerative, progressive disease. Using adjunctive therapies to complement traditional therapy is one possible strategy that could help maintain results as these strategies aim to aid and optimize the therapeutic process.

Electromyographic (EMG) biofeedback is one of the therapeutic strategies targeted to the rehabilitation of oropharyngeal dysphagia. It improves swallowing force and muscle coordination involved in the swallowing process, simultaneously associated with attention to cortical functions[14]. As an objective examination, the technique provides quantitative and qualitative physiological information and generates informative visual images that help understand the trained muscle, thus facilitating the rehabilitation process[15].

EMG biofeedback in neurogenic dysphagia has been used in stroke[16], Alzheimer's disease[17], and amyotrophic lateral sclerosis[18] cases, showing improved swallowing function and reduced incidence of adverse outcomes. A recent systematic review on PD cases included only two studies addressing the use of EMG biofeedback to treat dysphagia in that population[19]. One of the articles showed improved swallowing biomechanics and quality of life, indicating compelling evidence of the effectiveness of this new approach for rehabilitating altered swallowing function in subjects with PD[20]. The other refers to the thesis that originated the data in this article.

Once EMG biofeedback has shown positive results to improve the rehabilitation of oropharyngeal dysphagia for neurogenic cases, the technique's benefits could help maintain long-term, post-therapy results for older adults with PD. No studies were found in the literature applying this technique in long-term evaluation PD subjects.

Thus, this pilot study aimed to verify the influence of using EMG biofeedback as an assisting method to maintain long-term swallowing therapy results for older adults with Parkinson's disease in a prophylactic approach.

METHODS

The Institutional Review Board approved this prospective pilot study (No. 141/2011), and all participants signed an informed consent form. The study was conducted on six male subjects, aged 64 to 83 years (mean 73.17 years), diagnosed with dysphagia and PD, whose individual data are shown in Table 1.

The following inclusion criteria were considered: Diagnosis of PD by medical report at least six months beforehand with regular neurological follow-up; dysphagia confirmed through instrumental examination (videofluoroscopy or nasal endoscopy); good oral health with natural teeth or complete or partial dentures with good retention and stability; and Mini Mental State Examination[21] score compatible with their educational level. The exclusion criteria were other neurological disorders or cancer or not completing the therapeutic program proposed.

According to the signs of oropharyngeal dysphagia found via videofluoroscopy, the participants were assigned to two similar groups concerning their degree of dysphagia (Control group=CG; Experimental group=EG). Three subjects were only submitted to prophylactic speech-language therapy (PSLT) (CG), and the other three were submitted to PSLT associated with EMG biofeedback (EG).

The pre-therapy evaluation was completed seven to ten days before the speech-language intervention process, and re-evaluation was performed three to six months after the process completion. All procedures were performed on the same periods at all moments (before, three and six months after rehabilitation), respecting the peak effect of medications prescribed to treat PD. All assessment procedures were performed by a speech-language therapist who was experienced in the needed methods and blind to the research groups.

Table 1. Casuistry according to gender, age group, stage of Parkinson's disease (HY), cognitive status (Mini Mental), dysphagia severity (DOSS), and level of functional oral intake (FOIS)

Group	Patient	Gender	Age (years)	HY	Mini Mental (points)	DOSS	FOIS
CG	1	M	70	2	29	4	6
	2	M	73	3	34	5	7
	3	M	79	2	31	5	6
EG	4	M	64	2.5	32	5	7
	5	M	70	2.5	28	5	7
	6	M	83	2	29	4	6

Subtitle: CG = Control Group; **EG =** Experimental Group; **M =** Male

Evaluations

The study included applying a questionnaire on quality of life addressing the swallowing aspects and focused on oropharyngeal dysphagia (SWAL-QOL[22]), considering the overall score. The oral intake was also assessed, and the patients were scored according to the Functional Oral Intake Scale (FOIS) levels[23].

The videofluoroscopic evaluation of swallowing was performed in lateral view during regular mastication and swallowing of the following foods: (1) 1 cm thick half slice of a French bread roll (solid), (2) 10 ml of pudding food in a medium plastic spoon, and (3) 10 ml of water (liquid) offered in a syringe directly into the patient's mouth, all using barium sulfate contrast medium Bariogel®. The French bread roll received additional 5 ml of contrast medium; the pudding was prepared using 25 ml of filtered water, 2 grams of powdered diet grape drink Clight®, 15 ml of contrast medium and one measuring spoon of food thickener Nestlé Resource Thicken Up Clear®. The liquid was prepared using 10 ml of filtered water and 10 ml of contrast medium.

After instrumental evaluation of swallowing by videofluoroscopy, the subjects were classified according to their degree of swallowing dysfunction following the Dysphagia Outcome and Severity Scale (DOSS), which assigns the following levels: 7 (normal in all situations); 6 (functional swallowing); 5 (mild dysphagia); 4 (mild to moderate dysphagia); 3 (moderate dysphagia); 2 (moderately severe dysphagia); 1 (severe dysphagia)[24]. As previously stated, these data were used to define the group division according to the dysphagia severity.

Prophylactic Speech-language Therapy

The PSLT sessions were performed three times a week for five weeks. After completing the first 15 sessions, the subjects were followed to manage swallowing once a week for three weeks, totaling 18 sessions. Each therapy session lasted 50 to 60 minutes: approximately 30 minutes of indirect therapy and 30 minutes of direct therapy. All the sessions were conducted by the same speech-language therapist, which is not the same who performed the evaluation procedures.

All six subjects were submitted to PSLT for swallowing therapy in a prophylactic approach since all participants had few signs and symptoms of dysphagia, which corresponds to the initial stages of the disease. Orofacial, vocal, and respiratory exercises were applied according to the rehabilitation needs, based on oropharyngeal dysphagia diagnosis. Each subject performed vocal exercises selected after nasopharyngeal endoscopy examination of the speech function and therapeutic tests, with a positive or neutral outcome for vocal quality and laryngopharyngeal comfort.

The therapeutic strategies used for each participant in this study were (1) lip, tongue, cheek, and masseter isometric exercises, (2) lip and tongue isotonic exercises, (3) /a/ with laryngeal adduction, (4) /a/ in low frequency and /i/ in high frequency, (5) issuance of the sequence /mini/ in high frequency repeatedly; (6) /b/ prolonged, (7) emission of voiceless / voiced fricative consonant, (8) expiratory exercise, (9) swallowing training according to the strategy described by Crary, Carnaby-Mann, Griher, Helseth[25], and Mc Neill[26] using different food consistencies, (10) chin-down protective maneuver, and (11) Mendelsohn maneuver. The maneuvers were requested according to each subject's needs, and their efficacy was shown through instrumental examination.

PSLT associated with EMG biofeedback was conducted in three subjects with PD using the NeuroEDUCATOR® 4 electromyograph machine (four independent channels with real-time processing and bandwidth between 10-1,000 Hz). EMG biofeedback treatment strategies aimed to achieve neuromuscular adjustments to perform a suprahyoid muscle electromyographic record-enabled functional swallowing. For that purpose, in each session, the electrodes were positioned on the right and left masseter, orbicularis oris and suprahyoid muscles, parallel to the muscle fibers at a 2-cm distance. The subjects were sitting, and their skin-electrode contact area had been previously cleaned with alcohol-soaked cotton (70 °GL) to remove the excess grease and enhance fixation and signal capture. Muscle bioelectric potentials were captured through surface electrodes using a 3M conductive tape.

During training, subjects were shown their normal electromyographic pattern of swallowing and the pattern achieved, establishing a target tracing for each patient's functional training (Figure 1). In that training, patients performed the swallowing facilitating strategies, whose effectiveness was previously shown in the instrumental examination. Initially, the functional training was performed with saliva, and foods were introduced (pudding, solid, and liquid) as the function improved. The goal of such training was to make the neuromuscular recruitment as similar as possible to the target pattern of tracing, which involved an increased electromyographic signal amplitude for the suprahyoid muscles during function (greater muscle recruitment during function), improved coordination between the muscle groups involved in swallowing, and simultaneous control of the masseter and orbicularis oris muscles to avoid compensations. By doing that, patients could visually check the results of maneuvers and swallowing strategies used for direct training, allowing them to learn a new swallowing pattern. EMG biofeedback was not used during oral motor and vocal exercises.

The swallowing training was performed upon session completion without direct visual contact between patients and equipment, and later the results were analyzed to make sure they had learned regardless of the support. The subjects in this study did not perform exercises at home throughout the intervention.

RESULTS

PSLT (CG): The results showed improved quality of life considering the period before PSLT and after three months in all cases, with a decrease after six months in cases 1 and 3. There was increased oral intake after rehabilitation in cases 1 and 3, with maintained results in all moments in case 1 and return to the status seen before intervention in case 3. Case 2 did not present any dietary changes during the treatment. After the intervention, there was an improved degree of dysphagia with maintained results after three and six months of treatment in two cases (cases 1 and 2) and similar functional performance as observed before treatment, after both three months and after six months in case 3.

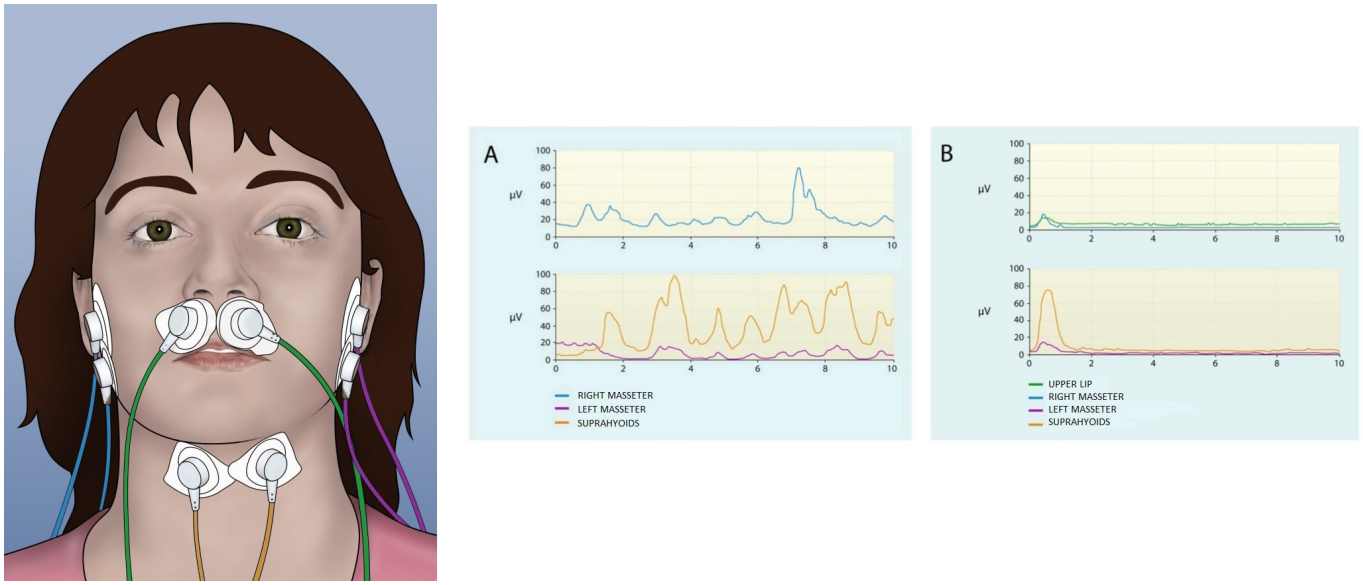

Figure 1. Electrode positioning and electromyographic recording corresponding to the suprahyoid musculature (yellow), upper orbicularis oris muscle (green), and right (blue) and left (purple) masseter activity during patient swallowing. Graph A represents the electromyographic pattern of patient's swallowing and the graph B therapy-driven target pattern.

Table 2. Results of quality of life assessment (SWAL-QOL), oral intake level (FOIS), and dysphagia severity (DOSS) of subjects submitted to PSLT and PSLT associated with electromyographic biofeedback

	PSLT								
	Clinical case 1			Clinical case 2			Clinical case 3		
	Pre	Post-3	Post-6	Pre	Post-3	Post-6	Pre	Post-3	Post-6
SWAL-QOL	60.79	91.48	79.54	74.43	84.09	84.09	72.16	88.07	84.66
FOIS	6	7	7	7	7	7	6	7	6
DOSS	4	5	5	5	6	6	5	5	5
	PSLT associated with EMG biofeedback								
	Clinical case 4			Clinical case 5			Clinical case 6		
	Pre	Post-3	Post-6	Pre	Post-3	Post-6	Pre	Post-3	Post-6
SWAL-QOL	87.50	83.52	85.22	86.93	89.77	89.77	78.41	90.91	81.25
FOIS	7	7	7	7	7	7	6	7	7
DOSS	5	6	6	5	6	5	4	5	5

Subtitle: PSLT = Prophylactic speech-language therapy

PSLT associated with EMG biofeedback (EG): Analysis of the quality of life revealed mild variation in outcomes in the different moments studied in case 4, improved results comparing the moments before and three months after therapy, with maintained results after six months in case 5 and considerable improvement after three months concerning before treatment in case 6, with reduced scores after six months for this subject. The oral intake maintained the maximum level for cases 4 and 5 and improved in case 6, with maintained results six months after treatment. After three months of rehabilitation for the three cases, there was an improved degree of dysphagia, with improvement maintenance achieved through therapy after six months for cases 4 and 6 and return to the status before therapy after six months for case 5.

Both groups benefited from the therapeutic modalities employed. One CG participant did not maintain their improvement concerning the oral intake level six months after treatment, while all patients submitted to EMG biofeedback maintained the benefits achieved (Table 2).

DISCUSSION

This study employed strategies commonly used in neurogenic cases for conventional swallowing rehabilitation speech-language therapy. However, in an unprecedented way, we proposed a prophylactic approach in this project since all participants were at early DP stages and therefore had early signs and symptoms of dysphagia. In our clinical practice, PD patients often seek speech-language therapy for dysphagia in later stages of the disease, when their swallowing is already severely impaired. The proposal for conducting PSLT was envisioned because prevention and prophylactic measures are important to avoid more serious long-term consequences in degenerative diseases as PD's evolution is expected to worsen the severity of dysphagia[10]. Previous studies on head and neck cancer found positive results for improving or maintaining aspects such as quality of life and oral intake through a prophylactic approach before treatment onset[11,12], which validates this research results.

PSLT with conventional strategies applied in both groups proved effective since it improved dysphagia and oral intake level. That confirms the data from another study[27], which reported an improved degree of dysphagia as assessed by a clinical evaluation protocol in older adults with neurogenic dysphagia treated with myofunctional exercises and postural maneuvers. Troche et al.[28] found improved penetration and aspiration scale scores in subjects with Parkinson's disease submitted to expiratory muscle force training. Different from our study, those articles performed post-therapy evaluation immediately upon completion of the therapeutic process.

Also, concerning the degree of dysphagia, the results found in subjects rehabilitated through conventional therapy associated with EMG biofeedback agree with other findings[29], which studied the degree of dysphagia in subjects after stroke treated with conventional therapy associated with EMG biofeedback and found an improvement after treatment.

No investigations were found assessing conventional therapy strategies' effect by applying the functional oral intake scale in subjects with PD. The subjects included in this research presented pre-therapy results in FOIS that suggested a preserved oral route. As patients already had good oral intake before the interventions, it was expected that the strategies could maintain good initial results. Since the oral intake level improved or remained stable after the interventions, we understood that the strategies applied were effective and can be considered a way to maintain the oral feeding route in the early phase of the dysphagia symptoms.

Studies applying EMG biofeedback to subjects after STR had a significantly improved oral intake level despite their samples comprising individuals, including alternative feeding techniques[25,29], while the cases in our study were within the maximum level defined by the scale.

The improvement in the quality of life after three months of conventional therapy shows that the feeding-related benefits positively influenced the study's participants' quality of life, similarly to the findings by Troche et al.[28]. Their study discovered improved quality of life in individuals with Parkinson's disease analyzed through the SWAL-QOL questionnaire, but their outcomes were not maintained over time. Besides the disease's progressive nature, as previously mentioned, the characteristics evaluated in the questionnaire should be considered, which include communication abilities, mental health, social functioning, sleep, and fatigue. Although these abilities are feeding-related, they may occur in isolation and reflect a worsening of the disease in aspects that are not treated by the therapy proposed in this study.

The improvement in the quality of life provided by speech-language therapy associated with EMG biofeedback in case 6 is related to the improvement in dysphagia and increased oral ingestion level, which may have influenced the high score in the quality of life achieved after three months of therapy. Studies with EMG biofeedback found in the literature did not investigate the quality of life, thus precluding comparisons. However, it should be considered that therapy periodicity and the need for regular follow-up of these patients may help maintain outcomes in the long term by allowing greater patient involvement in the intervention, which makes it easier to learn the swallowing pattern achieved through therapy and its automatization.

In general, the results achieved by conventional therapy were similar to the outcomes obtained through therapy associated with EMG biofeedback in the studied population. However, it should be mentioned that using EMG biofeedback may be an important strategy to maintain the benefits since all EG participants did not present any worsening of their degree of dysphagia despite the progressive nature of PD. Maintaining long-term results is key in PD cases and should be considered in the methodology of therapy programs[30], since it is a progressive disease and is expected to worsen swallowing parameters as it becomes worse[10].

Considering that this study comprised longitudinal follow-up, some interfering factors should be considered in the continuity of results, including disease evolution, prescription adjustments and even therapy periodicity. The participants in this study had progressive disease cases and, despite the intervention, such disease and its related clinical signs and symptoms evolved. Thus, one can relate the prescription changes, which are essential to treatment adjustment due to the clinical status, which may impact the rehabilitation process.

Despite our pilot study limitations regarding the number of patients, it will guide future projects. Future studies on a greater number of participants of different age ranges and greater severity of changes in their swallowing physiology may evidence the results suggested in this study and guide the use of more effective rehabilitation strategies for patients with PD. Evaluation instruments that quantify the qualitative data, such as oral and pharyngeal transit time or measurement of the hyoid excursion, should also be considered as they allow objective analyses despite not providing swallowing-related information of individuals with mild impairment.

CONCLUSION

Both therapy modalities with PSLT resulted in improved quality of life, oral intake level, and severity of dysphagia, but the benefits were maintained over time only for participants in the experimental group.

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