

Effect of overarticulation technique in voice and speech of individuals with Parkinson's disease with deep brain stimulation

Efeito da técnica de sobrearticulação na voz e na fala em indivíduos com doença de Parkinson após cirurgia de estimulação cerebral profunda

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ABSTRACT

Purpose: To verify the immediate and after 15 minutes effect of the overarticulation technique in individuals with Parkinson's disease, submitted to deep brain stimulation in subthalamic nucleus, in the voice, speech and facial movements. **Methods:** This study counted with 29 patients with the diagnosis of Parkinson Disease who were undergoing pharmacotherapy and were submitted to deep brain stimulation in the subthalamic nucleus, with and without prior speech therapy. Speech and voice samples were recorded in an audio and video file at three different moments: pre-intervention, immediate post intervention and 15 minutes post intervention. The intervention was the individual performance of 5 minutes exercise consisting of sequence of overarticulation techniques. The audio and video recordings were submitted to the perceptual-judgement of the voice quality and facial movements. **Results:** The technique produced positive results in 69% of the cases after 15 minutes of its application when compared to the other moments. Articulation was the parameter that most contributed in the perceptual-judgment of the best voice quality (69%); it was significantly higher than the other parameters, except speech rate. After 15 minutes of the technique, 58.6% of the patients had improvement in the facial movements, according to the perceptual-judgment which was also significantly better when compared to other moments. The parameter with greater improvement was movement of the mouth, eyebrows and eyes. **Conclusion:** The overarticulation technique produces an immediate positive effect on vocal aspects and greater facial expressiveness, especially after 15 minutes.

Keywords: Deep brain stimulation; Parkinson disease; Hypokinetic dysarthria; Voice; Speech

RESUMO

Objetivo: Verificar o efeito imediato e após 15 minutos da técnica de sobrearticulação de fala em indivíduos com doença de Parkinson, submetidos à estimulação cerebral profunda em núcleo subtalâmico, nos parâmetros de voz, fala e mímica facial. **Métodos:** Participaram 29 sujeitos com diagnóstico médico de doença de Parkinson, sob tratamento medicamentoso e submetidos à estimulação cerebral profunda em núcleo subtalâmico, com e sem reabilitação fonoaudiológica prévia. Realizou-se gravação em áudio e vídeo de amostra de fala e voz em três momentos: pré-intervenção, pós-imediato e após 15 minutos da realização individual de cinco minutos de uma sequência de exercícios de sobrearticulação de fala. As gravações foram submetidas à avaliação perceptivo-auditiva da voz e perceptivo-visual da mímica facial. **Resultados:** A técnica produziu resultados positivos em 69% dos casos, após 15 minutos de aplicação, em relação aos demais momentos. O parâmetro que mais contribuiu para a identificação da melhor emissão na avaliação perceptivo-auditiva foi articulação (69%), significativamente maior que os demais parâmetros, exceto velocidade de fala. A análise perceptivo-visual mostrou melhora em 58,6% dos casos após 15 minutos, também significativamente melhor que os demais momentos. O parâmetro em que se observou maior proporção de melhora foi na movimentação de boca, sobrancelhas e olhos. **Conclusão:** A técnica de sobrearticulação de fala produz efeito positivo imediato nos aspectos vocais e uma maior expressividade facial, principalmente após 15 minutos de realização.

Palavras-chave: Estimulação cerebral profunda; Doença de Parkinson; Disartria hipocinética; Voz; Fala

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INTRODUCTION

The Parkinson's disease (PD) is a neurodegenerative disease, of unknown a etiology, that results from the death of dopamine producing neurons in the substantia nigra of the mesencephalon; important neurotransmitter responsible for the motor control⁽¹⁾. The loss of the substantia nigra impacts the central control of movement⁽²⁾ and significantly generates changes in voice and speech⁽³⁾.

For the majority of patients, the PD begins after their 55th birthday, the disease prevalence increases when the patient has more than 70 years old. Currently, the PD incidence in the Brazilian population is 150 to 200 patients per 100,000 inhabitants, in other words, there is one PD patient for each 1,000 inhabitants⁽⁴⁾.

The PD is a clinical diagnosis; it is based on primary symptoms, which can be isolated or combined: rest tremor, stiffness, bradykinesia and loss of postural reflex. It is estimated that, at the time of the diagnosis, the individual has already lost over 50% of the gray matter, which reinforces the importance of an early diagnosis⁽⁴⁾.

In addition to the first symptoms, the PD patient may present speech and voice symptoms, known as hypokinetic dysarthria. These symptoms impair the communication; this condition is known as motor speech disorders. There are some cases that the speech and voice symptoms are identified even before the medical diagnosis of PD. These symptoms are usually: imprecise consonant articulation; monopitch, slurred speech, weak voice with monoloudness, presence of asthenia, breathiness, roughness and hypernasal resonance⁽⁵⁾.

These characteristic vocal symptoms of PD, are due to the reduced vocal fold mobility, large mucosal wave, spindle-shaped glottic chink, arytenoid tremor and anteroposterior and medial constriction⁽⁵⁾. These manifestations are developed during the course of the disease⁽⁶⁾, which increases the intensity of the symptoms and may lead to dysphagia⁽⁵⁾.

Speech therapy for voice and swallowing problems in patients with PD is generally associated with pharmacological treatment, based on levodopa, which is the endogenous dopamine precursor⁽⁷⁾. Both improve all the altered motor parameters in the disease⁽⁸⁾. It is known that combined methods may better assist the communication rehabilitation, like the Lee Silverman Voice Treatment (LSVT) associated with other techniques such as speech overarticulation^(5,9).

In the last two decades, Deep Brain Stimulation (DBS) has been studied as a complementary surgical alternative for the reduction of motor symptoms. It consists of an electrical device implanted in the thalamus, subthalamic nucleus (STN), Globus pallidus (GPi) or in the ventral internal nucleus (VIN). This type of treatment must be chosen in accordance to the neurologist clinical evaluation^(7,10). Improvement in all motor symptoms was observed after the DBS, except for speech and swallowing^(6,11). The voice and speech function observed after the DBS implant were: strain voice with low loudness, including laryngeal, respiratory and articulatory alterations. Taking this into account, the LSVT Method is not the best treatment, since it is more adequate for laryngeal hypofunction. Therefore, more focused approaches addressing these symptoms may give more consistent results.

Considering that speech gets worse after the DBS, to perform articulatory exercises may improve the oral communication.

Therefore, the aim of this study was to verify the immediate and after 15 minutes effect of overarticulation technique in individuals with PD submitted to deep brain stimulation of subthalamic nucleus (DBS-STN), in voice, speech and facial movements parameters.

METHODS

This is a prospective research approved by the Committee for Ethics in Research of the *Universidade de Taubaté*, under the protocol number 1.365.411. The research counted with 29 individuals with medical diagnosis of Parkinson Disease, men and women, that were submitted to DBS-STN and that sought for speech-language pathologist evaluation at a Parkinson Disease association in the state of *São Paulo*, Brazil. All patients agreed to participate and signed an informed consent form.

The inclusion criteria were: medical diagnosis of PD, with at least five years from the beginning of symptoms, submitted to DBS-STN; presence of communication problems; stable medication use, in order to avoid unstable symptoms in voice and speech performance; speak Brazilian Portuguese; have no history of other neurological or psychiatric diseases. The patient was not excluded due to previous speech therapy once this study focused on the immediate effect of the intervention. In addition, prior therapy focusing on speech and voice symptoms, previously to the DBS, does not guarantee absence of signs and symptoms regarding speech and voice post deep brain stimulation.

The exclusion criteria were: medical diagnosis of PD submitted to DBS-STN in patients with loss of teeth or maladaptation of dental prosthesis; presence of auditory complaints; alteration in the temporomandibular joint; upper airway infections and / or nose and throat allergy at the recording moment; other communication problems or language alterations; depression and cognitive alterations.

Videos recordings of the patients were made using an Ipad Air, model A1474 16gb 4g by Apple. The recordings were performed in a quiet room. The patients were instructed to say the months of the year and to count the numbers from one to 20. The recordings were done in three different moments: pre-intervention, immediate post intervention and 15 minutes post intervention. The intervention consisted of overarticulation exercises, from the "Speech Method"⁽⁵⁾. The steps in the data collection were as follows: pre-intervention recording; five minutes of exercise; immediate post-intervention recording; 15 minutes interval; 15 minutes post intervention recording. The sequence of exercises was performed individually, it lasted five minutes and it was applied by the same therapist, who also gave the instructions, examples and feedbacks so that the patient would perform the exercises correctly. The sequence of exercises was as follows: 1 - five repetitions of the vowels "a", "e", "i", "o", "u", with an exaggerated articulation and regular speech rate; 2 - count the numbers from one to 20 with an exaggerated articulation and regular speech rate; 3 - say the days of the week, with an exaggerated mouth opening; 4 - repeat once the sequence: PA TA KA/ BA DA GA/ MA NA NHA/ FA SA CHA/ VA ZA JA/ LA RA RA with an exaggerated articulation, regular speech rate using visual feedback.

During the recordings, the patients were seated at the same place with trunk and neck in erect position and looking to the Ipad camera, that was positioned on sufficient distance to frame the patient's face.

The collected video and audio samples were edited and randomized. Two voice specialists perceptually-judged these samples regarding the voice quality and facial movements; there was 40% of repetition to assess the intra-rater reliability. Three videos of the same patient were randomly presented to the evaluators in order Perceptual-auditory judgement protocol to assess voice and speech of the Parkinsonians/Protocol for the perceptual-auditory judgement of voice and speech for the Parkinson Disease Patient for them to perform the analysis; the videos were from the pre-intervention, the immediate post intervention and 15 minutes post intervention moments. The was used for voice and speech evaluations. Considering the three videos of each patient, the raters had to indicate which sample they considered the best or indicate that there was no difference; if one of the videos was considered to be the best they had to justify their choice. For these cases, the best parameter had to be indicated. Following are the definition of each parameter:

Voice quality: the voice quality must be neutral; thus, no deviation should be observed such as: hoarseness, low pitch, high pitch or monotone.

Resonance: the resonance must be adequate, without compensation of any other vocal tract structure; without low, nasal or oral resonances.

Pitch: should be in accordance with the speaker gender and age. This parameter is related to the speech intention, that is, with the intention of the message the speaker wishes to share. It can be classified as low, normal, i.e., typical, or high.

Loudness: should be related to the speech topic. It is important to observe if it is normal voice, loud or quiet voice.

Vocal projection: it is the outcome of an emission with adequate volume, loudness and pitch.

Speech rate: it is closely related to the articulation of speech sounds. When the speech rate is fast, the speech sounds will not be very well defined. On the other hand, extremely slow speech rate is monotonous, thus, the listener will not pay much attention. Therefore, the speech rate should be in accordance with the spoken topic, not too fast and not too slow.

For the visual perceptual-judgment of facial movements, the evaluators randomly watched three videos of the same

patient, in the pre-intervention, immediate post intervention and 15 minutes post intervention moments. To evaluate the facial movements, eyebrows, eyes and mouth movements were observed⁽¹²⁾. The non-verbal information is mainly shown by the facial expression and it reveals emotional states; it includes eye contact, eyebrow movements and facial movement, that will change according to the speaker intention and emotion behind the spoken message. The evaluators watched the videos of the three recording moments and selected the best one and indicated if there was more movement in the upper or inferior third of the face or even in both.

The data from the perceptual-judgement of the voice quality and facial movements were submitted to statistical analysis. All analyses were performed with the software SPSS 17.0 and Minitab 16.0. The significance level was set at 10%. The Kappa coefficient was used to analyze the intra and inter-rater reliability. Only substantial or almost perfect (0.610 to 0.800, substantial; above 0.810, almost perfect) Kappa values were considered. Also, the equality of two proportions test was used to compare the sample that was considered the best by each evaluator and by both evaluators together, considering the judgement of the voice quality and facial movements.

RESULTS

Regarding the perceptual-judgment of the voice quality, the best moment for most patients was at 15 minutes post intervention (n=20; 69%), with no difference in the other moments (pre-intervention - $p < 0.001$, immediate post intervention - $p < 0.001$). The parameters that contributed the most to the identification of the best voice emission were: articulation of speech sounds (n=20, 69%), speech rate (n=15, 51.7%), loudness (n=9; 31%), vocal projection (n=7, 24.1%) and resonance (n=6, 20.7%). The parameter of articulation of speech sounds was statistically different from the other parameters, except speech rate (Table 1 and Table 2).

Regarding the perceptual-judgment of facial movements, the best moment also was at 15 minutes post intervention

Table 1. Distribution of the best emission in the three moments for perceptual-judgement of voice

Moment	Rater 1			Rater 2			Both		
	n	%	p-value	n	%	p-value	n	%	p-value
Pre	3	10.30%	<0.001*	3	10.30%	<0.001*	3	10.30%	<0.001*
Immediate post	6	20.70%	<0.001*	6	20.70%	<0.001*	6	20.70%	<0.001*
15 m post	20	69.00%	Ref.	20	69.00%	Ref.	20	69.00%	Ref.

Equality of two proportions test; * $p < 0.05$

Subtitle: n = number; % = percentage; 15 m = 15 minutes; Ref = reference value

Table 2. Distribution of the best parameters in the perceptual-judgement of voice

Parameters	Rater 1			Rater 2			Both		
	n	%	p-value	n	%	p-value	n	%	p-value
Resonance	6	20.70%	<0.001*	6	20.70%	<0.001*	6	20.70%	<0.001*
Pitch	0	0.00%	<0.001*	0	0.00%	<0.001*	0	0.00%	<0.001*
Loudness	9	31.00%	0.004*	9	31.00%	0.004*	9	31.00%	<0.001*
Articulation	20	69.00%	Ref.	20	69.00%	Ref.	20	69.00%	Ref.
Vocal Projection	7	24.10%	<0.001*	7	24.10%	<0.001*	7	24.10%	<0.001*
Speech rate	15	51.70%	0.180	15	51.70%	0.180	15	51.70%	0.058

Equality of two proportions test; * $p < 0.05$

Subtitle: n = number; % = percentage; Ref = reference value

(n=17, 58.6%); this parameter was significantly higher when compared to the other moments (pre-intervention - $p < 0.001$, immediate post intervention - $p < 0.001$). It was observed more movement of the mouth, eyebrows and eyes (n=14; 48.30%), followed by eyebrows and eyes (n=8, 27.6%) and mouth alone (n=7; 24.1%). A greater improvement was noticed in the movement of the mouth, eyebrows and eyes than for mouth alone ($p=0.012$) or eyebrows and eyes ($p=0.034$) (Table 3 and Table 4).

The answers of both evaluators were considered once the intra-rater reliability values, for both perceptual judgments, was different; the evaluator 2 had moderate kappa, 0.49. The inter-rater reliability agreement was almost perfect for the perceptual judgement of the voice quality, the highest value was 1.000; there was no agreement on the perceptual-judgment of facial movements, 0.094.

DISCUSSION

The PD, beside involving changes, such as tremor, muscle stiffness, slow movement and posture alteration, can also affect communication, which happens in 89% of the cases^(4,5). The oral communication changes in patients with PD are mainly due to nervous degeneration, which blocks neuromuscular transmission and generates difficulties to quickly and easily begin, maintain and execute motor activities, that are essential to guarantee good and intelligible voice and speech functions⁽¹³⁻¹⁶⁾. Thus, articulation is the most compromised aspect in oral communication⁽¹⁷⁾ affecting from 67%⁽¹⁸⁾ up to 80% of the PD patients⁽¹⁹⁾. The main alteration is articulatory inaccuracy, that can be altered due to different reasons, such as lack of adequate vocal tract narrowing in the production of the phonemes, or due to decreased movement of the articulatory muscles; this decreased movement can be caused by deficits in the coordination of agonist and antagonist muscles, or by limited vertical opening of the mouth due to the stiffness of the jaw lift, masseter and temporal muscles. In patients without DBS, it seems that speech therapy that aims to improve phonatory task⁽⁹⁾, indirectly, provides better articulation of speech sounds. However, this approach is not recommended in cases post DBS, were one of the vocal characteristics is laryngeal hyperfunction.

The changes that affects the PD patient communication can negatively influence their self-esteem, safety and quality of life. Treatments that aim to reduce these symptoms and improve the quality of life are available; usually they are based in pharmacotherapy, psychotherapy and surgery. One recent treatment strategy for PD patients is the DBS; it has shown satisfactory outcomes regarding the cardinal motor symptoms. However, the oral communication impacts are reserved, there are negative impacts on the speech intelligibility, that includes worse voice quality (asthenia and breathiness) and that negatively impacts vocal loudness and pitch⁽²⁰⁾. Also, the DBS in PD patients was frequently observed to increase respiratory driving pressure and to increase vocal fold closure; less frequently, to impact voice and speech⁽⁶⁾, and to be less beneficial for speech-related respiratory control resulting in worse intelligibility⁽¹¹⁾. Therefore, it can be observed that, after DBS, some patients may have little negative impact while others may have big impact, i.e., bad communication pattern⁽⁶⁾. This states for the need of proper speech therapy for DBS patients considering that the therapy may guarantee better functionality and speech intelligibility⁽²¹⁾.

Many techniques are used to reduce the PD symptoms, such as the overarticulation technique; that was the focus of the present study due to high reports in the literature of its benefits in articulation. This technique belongs to the "Speech Method"⁽⁵⁾; its performance is based on the exaggerated articulation of speech sounds by making large vertical opening of the mouth. To guarantee the exercise high precision, the patient must pay attention to each sound that is being said, however, he must not increase the tonus of the larynx. This exercise mainly addresses to the vocal tract; indirectly it addresses to the voice quality, once it also changes voice characteristics⁽²²⁾. The overarticulation technique aims to reduce laryngeal hypertonicity, increase vocal volume and loudness: increase vocal resistance and slow speech rate⁽²³⁾. Thus, the present study aimed to verify the immediate and after 15 minutes effect of overarticulation technique in individuals with PD.

Two voice specialists were asked to indicate the best sample out of three samples or to indicate that there was no difference. Next, they had to justify their choice. To identify the best emission the raters performed the perceptual-judgement of the voice quality and facial movements in each moment, i.e., pre-intervention, immediate post intervention and 15 minutes post intervention. The best emissions were identified at 15 minutes

Table 3. Distribution of the best emission in the three moments for perceptual-judgement of facial movements

Moment	Rater 1			Rater 2			Both		
	n	%	p-value	n	%	p-value	n	%	p-value
Pre	6	20.70%	0.003*	7	24.20%	0.008*	7	24.20%	<0.001*
Immediate post	6	20.70%	0.003*	5	17.20%	0.001*	5	17.20%	<0.001*
15 m post	17	58.60%	Ref.	17	58.60%	Ref.	17	58.60%	Ref.

Equality of two proportions test; * $p < 0.05$

Subtittle: n = number; % = percentage; 15 m = 15 minutes; Ref = reference value

Table 4. Distribution of the best parameters in the perceptual-judgement of facial movements

Parameters	Rater 1			Rater 2			Both		
	n	%	p-value	n	n	%	p-value	%	N
Eyebrows and eyes	7	24.10%	0.256	9	31.00%	0.035*	8	27.60%	0.034*
Mouth	11	37.90%	Ref.	3	10.30%	<0.001*	7	24.10%	0.012*
Eyebrows, eyes and mouth	10	34.50%	0.785	17	58.60%	Ref.	14	48.30%	Ref.

Equality of two proportions test; * $p < 0.05$

Subtittle: n = number; % = percentage; Ref = reference value

post intervention, both considering the perceptual-judgement of voice quality and facial movements.

The outcomes showed that the use of an exercise sequence that included overarticulation technique can improve communication and that this improvement is still present for at least 15 minutes. Data from the literature shows that the effects on the speech⁽²⁴⁾ of PD patients with DBS are particular; some patients get worse while others do not. However, in most cases the treatment does not change the speech pattern⁽²⁵⁾, like other pharmacological treatments⁽²⁴⁾.

Regarding the rehabilitation using vocal exercises, the LSVT is the treatment most common and used worldwide, despite the stage of the PD⁽²⁴⁾. Although with different exercises and different duration of the intervention, the vocal training in the LSVT is intense, with daily session that happens during one month, the maintenance of the results after the LSVT intervention has been proven⁽⁹⁾ and it can be maintained for at least two to three years⁽²⁴⁾. However, no studies that analyzed the effects of vocal techniques for patients with PD treated with DB were found, once the DBS is considered to be a treatment⁽²⁴⁾.

The parameters that most contributed to identify the best emission, considering the perceptual-judgement of the voice quality, were articulation of speech sounds, speech rate and loudness. These parameters are directly influenced by the technique; their improvement shows that the technique was effective. The articulation of speech sounds improved more often when compared to the other parameters, except speech rate. The better outcome in this parameter might have been due to the exercise execution, related to the speech and voice motor gesture of the selected tasks. The improvement in speech rate, that is, the improvement of this parameter, when compared to the other two, without considering it to be faster or slower, may be related to its close relation to the articulation of speech sounds; when not so fast it favors the precision of all sounds in each word, when not so slow it keeps the listener's attention. On the other hand, loudness may have improved due to greater vertical opening of the mouth, which favors vocal projection, related to louder vocal loudness.

Other studies regarding speech therapy in patients with PD that focused on phonation, not articulation, observed improvements in glottal efficiency⁽²⁶⁾ and in vocal loudness, that were still observed after 12 months; also, the louder loudness was related to the higher intraoral pressure⁽²⁷⁾. Some studies report better vocal quality and louder vocal loudness after speech therapy that focused on phonation, LSVT; however, there was no improvement in articulation^(17,28). The present study, confirmed that louder vocal loudness is related to overarticulation training technique.

Considering the perceptual-judgement of facial movements, greater movement of the eyebrows, mouth and eyes, followed by eyebrows and eyes and mouth alone were observed, based on the factors related to facial expressiveness⁽¹⁵⁾. The improvement in eyebrows, eyes and mouth movement was significantly higher than the improvement of isolated parameters. Facial expression is considered to be the main source of non-verbal information, it shows the person's emotional state. The eyes are extremely expressive and added to the eyebrow's movement, they can express almost all types of feelings. Bright eyes express enthusiasm, joy and life, while dull eyes express disappointment and sadness. Low eyebrows express concentration, reflection and seriousness; while high eyebrows, surprise, shock, displeasure or joy. There are reports of greater facial mobility and expression after the

LSVT, which shows the indirect impact that phonation tasks alone have on facial movement⁽¹⁰⁾.

In addition to aspects related to speech intention, better facial movement may facilitate vertical opening of the mouth. Therefore, louder loudness and more flexibility to pronounce each phoneme which guarantees better visual analysis of facial movements.

The overarticulation technique does not focus on voice, it promotes vocal tract adjustments, better definition of articulation points and greater awareness of breathing, as well as better breathing and speaking coordination, with more vocal projection⁽²⁹⁾. This technique is an option for the rehabilitation of patients with PD⁽³⁰⁾, including those submitted to DBS-STN. The data observed in the present study showed that this technique can provide louder vocal loudness and better articulation precision, most evident improvements after the technique, which offers better anatomo-physiological conditions for the PD patients' communication. However, the inclusion of other exercises, that focus on phonation is necessary; once they will increase glottal resistance providing better vocal production.

It is known that voice and speech training favors the coordination of oral structures and increases vocal projection; thus, it provides more mobility and elasticity of the facial musculature. In this way, this training can harmonize the speech subsystems and allow better integration of voice and speech functions with facial expressiveness; hence, it is an option for communication limitations post DBS. This technique added to an intensive training may be positive in the expressiveness post DBS, which agrees with the assumption that training one (articulation) of the many (speech and voice, facial movement and gestures) parameters of expressiveness can be effective and efficient to improve the overall expressiveness^(17,31).

Further studies are needed to verify the long-term effects in the voice, speech and facial movements related to the overarticulation technique in patients with PD who underwent DBS.

CONCLUSION

The overarticulation technique sequence is an option for dysarthria rehabilitation after deep brain stimulation in the subthalamic nucleus in patients with PD. It has immediate positive effects that are kept after 15 minutes, both in vocal aspects, promoting speech intelligibility due to better articulation of speech sounds and speech rate, and in facial movements features, promoting greater expressiveness and optimizing the global facial movement.

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