Original Article

Effects of orthodontic treatment with aligners and fixed appliances on speech:
A randomized clinical trial

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ABSTRACT

Objectives: To evaluate effects of orthodontic treatment with aligners and conventional fixed appliances on production of speech.

Materials and Methods: This was a parallel, randomized clinical trial. Patients with Angle Class I malocclusion, moderate crowding, and no speech impairment were randomly allocated to two groups: patients with orthodontic aligners (OAs; n = 20; mean age = 23.60 ± 5.65 years) and those with conventional fixed appliances (n = 20; mean age = 20.56 ± 4.51 years) and treated at the University of North Parana's clinic in Londrina, Brazil. Evaluation of speech production was performed semiobjectively by a speech therapist (myofunctional orofacial examination) and subjectively (self-assessment) at five time points: baseline, immediately after insertion of appliances, and subsequently at 3, 30, and 180 days after insertion. For intergroup comparison, independent t, χ^2, Fisher exact, and Mann-Whitney tests were used; for intragroup comparison, the Friedman test was applied ($\alpha = 5\%$).

Results: In the semiobjective evaluation, patients with OAs exhibited a change in production of speech production, compared with patients with fixed appliances, immediately and 3 days after insertion of appliances ($P < .001$). Thirty days after insertion, the groups were similar ($P = .487$), an outcome that was unchanged at 180 days. However, in the self-assessments, patients in both groups reported significant speech difficulties immediately and 3 days after insertion of appliances, but such impairment was no longer perceived at 30 days or 180 days.

Conclusions: Although the speech therapist identified changes in speech production at the start of treatment in the OA group only, patient self-assessments demonstrated that orthodontic treatment, regardless of the type of appliance used, interfered with their perception of speech. (*Angle Orthod.* 2021;91:711–717.)

KEY WORDS: Orthodontics; Fixed appliance therapy; Aligner; Speech

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INTRODUCTION

A smile's appearance has a big impact on a person's ability to communicate interpersonally. Therefore, there is growing interest among adult patients to undergo orthodontic treatment that does not impair facial appearance.[1] In this regard, esthetic appliances, such as orthodontic aligners (OAs), have emerged as alternatives to metal fixed appliances (FAs).[2]

Difficulty with speech is known to be one of the main adverse effects of orthodontic treatment.[3] Acquisition of precise speech production, with no distortions and/or changes, is an important detail to be considered when selecting the appropriate orthodontic appliance. Orthodontic appliances can reduce intraoral space, can

adversely affect tongue movement, and, consequently, result in the distortion of certain specific sounds.[4] In this context, Wan et al.[5] evaluated the effects of using removable retainers (Hawley and vacuum-formed retainers) on changes in speech articulation in adult patients between 19 and 29 years old after active orthodontic treatment. The patients exhibited distorted speech articulation, regardless of retainer type; however, speech articulation distortion was more apparent in patients using Hawley retainers.

Nedwed and Miethke,[6] in a prospective study, used a questionnaire to evaluate acceptance, comfort, and potential impairment of patients' speech after 3 and 6 months of treatment with OAs. The results showed that 53.8% of the patients had impaired speech; of these, just 1.9% reported a severe change, while 51.9% exhibited a slight alteration. Additionally, 7.4% of patients reported that the use of an OA adversely affected their oral communication. Pogal-Sussman-Gandia et al.,[7] in a cross-sectional study, also evaluated patients treated exclusively with OAs and found modifications in the fricative consonants /z/ and /s/, with changes in the production of speech, which could affect the patient's adherence to treatment. In the observational, retrospective study conducted by Alajmi et al.,[8] the patients who underwent treatment with aligners and fixed orthodontic appliances reported difficulty with speech, particularly those patients who used aligners; however, the degree of satisfaction was no different between the treatments. Still, the authors pointed to several limitations in the design and execution of the study, such as the lack of rigidity of inclusion criteria with regard to patient availability and willingness to participate, the significant disparity in age within the groups, stage of treatment, and type of tooth movement. The authors also identified the need to conduct a randomized clinical study to confirm their results.

Given the scarcity of randomized clinical studies on this topic, the aim of this study was to evaluate speech production in patients undergoing orthodontic treatment with OAs and FAs.

MATERIALS AND METHODS

Trial Design

This study was a parallel, randomized, controlled clinical trial, in which participants were recruited prospectively and randomly divided into two groups. No changes in the methods occurred after the trial began.

Participants, Eligibility Criteria, and Settings

The sample was obtained by screening 2662 individuals assessed in the city of Londrina, Brazil.

Participants who met the following criteria were included: 13–35 years old, Angle Class I malocclusion, moderate crowding, and treatment without extraction. The exclusion criteria were absence of permanent teeth, anterior or posterior open and crossbite, previous history of orthodontic treatment, and changes in the production of speech.

The research was approved by the Ethics Committee of the University of North Parana (UNOPAR) (CAAE:12088219.0.0000.0108) and registered in Brazilian Clinical Trials (ReBEC:RBR-9zytwf). Volunteers received treatment at UNOPAR's clinic and were assisted by orthodontists supervised by an orthodontic professor with 15 years' experience.

Interventions

Patients were randomly allocated into two groups:

- OAs (Smart Track, Invisalign, Align Technology, San Jose, CA, USA): virtual planning was accomplished for this group (ClinCheck Pro program, version 5.6, Align Technology). The sequence of procedures during treatment with aligners followed the virtual plan. The pairs of upper and lower OAs were changed every 10 days, with recommended daily wear of 22 hours.
- FA, fixed metallic orthodontic appliances (slot 0.022 × 0.030", 3M Unitek, Monrovia, Calif): these patients had appliances attached to all teeth and the same sequence of archwires (superelastic nitinol 0.014", 0.016", and 0.016 × 0.022").

For both groups, monitoring procedures were performed monthly. For this study, the results obtained in the first 6 months were recorded and analyzed.

Outcomes (Primary and Secondary)

Speech evaluation. Speech evaluation was conducted by a speech therapist, an oral motor specialist with more than 30 years' experience.

- Orofacial myofunctional evaluation with scores protocol[9]: performed before treatment began (baseline), with the aim of evaluating the stomatognathic functions and discarding interference with the production of speech;
- Orofacial Myofunctional Examination (MBGR)[10]: conducted by an external examiner for the perceptive-auditive speech analysis, in which the patients were asked to pronounce the names of figures on a clipboard, recorded by way of standardized filming with a camera (Canon Power Shot SX60 HS, Canon Co., Tokyo, Japan) installed on a stand 1 me away from the volunteers. Patients were seated in a chair

with a backrest in a private room, with their feet resting on the floor and their head leaning slightly forward to facilitate viewing the figures to be pronounced. The assessment was conducted at five time points: baseline, immediately after appliance insertion, and after 3, 30, and 180 days. After recordings were performed at all time points, they were evaluated using earphones only by the speech therapist, who was blinded to the participant. The therapist could not see patients' faces and did not know to which group each patient belonged.

Self-assessment. The perception of speech production (self-assessment) was measured using a visual analog scale (VAS). Participants were instructed to make a vertical line crossing a 10-cm horizontal line to indicate current speech perception, with the left end representing ''no speech alteration/no speech difficulty'' and the right end representing "extreme difficulty in speech/great difficulty in speaking." Patients completed the VAS at the same five time points that the MBGR was conducted.

Sample-Size Calculation

The sample-size calculation was based on a previous study[5] that evaluated the effects of the use of removable retainers on speech. In order to be able to detect a difference in the proportion of alterations between the two groups of 0.5 with alpha-type error set at 5% and power at 80%, it was necessary to recruit a minimum of 18 participants per group. The calculation was performed using the program G-Power 3.1 (Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany).

Interim Analyses and Stopping Guidelines

Not applicable.

Randomization

Simple randomization[11] was performed by an external researcher, using the Excel 2007 program (Microsoft Windows, Microsoft, Chicago, Ill), in a proportion of 1:1. The randomization codes were inserted in opaque, sealed, numbered envelopes, consecutively, ensuring concealment of the allocation into the two groups.

Blinding

The MBGR analysis performed by the speech therapist was carried out blindly.

Statistical Analyses

To check the speech therapist's reliability, 30% of the analyses were repeated, and the results were tested using a Kappa test. The data obtained were verified for normality (Shapiro-Wilk test). Intergroup comparisons were performed using the independent t, χ^2, Fisher exact, and Mann-Whitney tests. For intragroup comparisons, the Friedman test was applied. Statistical treatment was performed using SPSS 26.0 (SPSS Inc, Chicago, Ill), with a significance level of 5%.

Risks and Benefits

The two appliances presented some minimal risk inherent to orthodontic treatment, namely, slight shortening of the tooth root and mild discomfort after the monthly visits.

RESULTS

Participant Flow

Figure 1 shows the flowchart of patients assessed for eligibility, randomization, allocation, and monitoring in the first 6 months of treatment. Participants who met the inclusion criteria were recruited between August 2018 and February 2019. A total of 52 patients met the criteria, although only 40 showed interest in participating. Orthodontic examinations were performed in February 2019. In May 2019, patients came for a postrandomization (baseline) appointment, appliance insertion, and instructions. They returned once a month for monitoring over a period of 6 months; follow-up examinations were performed in November 2019.

Baseline Data

Participants in both groups demonstrated compatibility in terms of age, sex, Peer Assessment Rating index and Little's Irregularity Index (Table 1). No patient in the sample had speech impairment at baseline.

Outcome Data

Perfect reproducibility (kappa = 1.00) was obtained for the speech therapist analyses.

Patients who used OAs exhibited significant changes in speech production, compared with patients with FAs, immediately after insertion until 3 days after start of treatment ($P <$ .001). However, at the evaluation 30 days after treatment began, the groups were similar (P = .487) (Table 2).

Among the changes in speech production found between the two groups, it was noted that the phoneme /ch/ was responsible for the change. The change in articulation of the phoneme /ch/ was significant in patients with OAs immediately after insertion and 3 days after treatment began. Immedi-

C O N S O R T
TRANSPARENT REPORTING of TRIALS
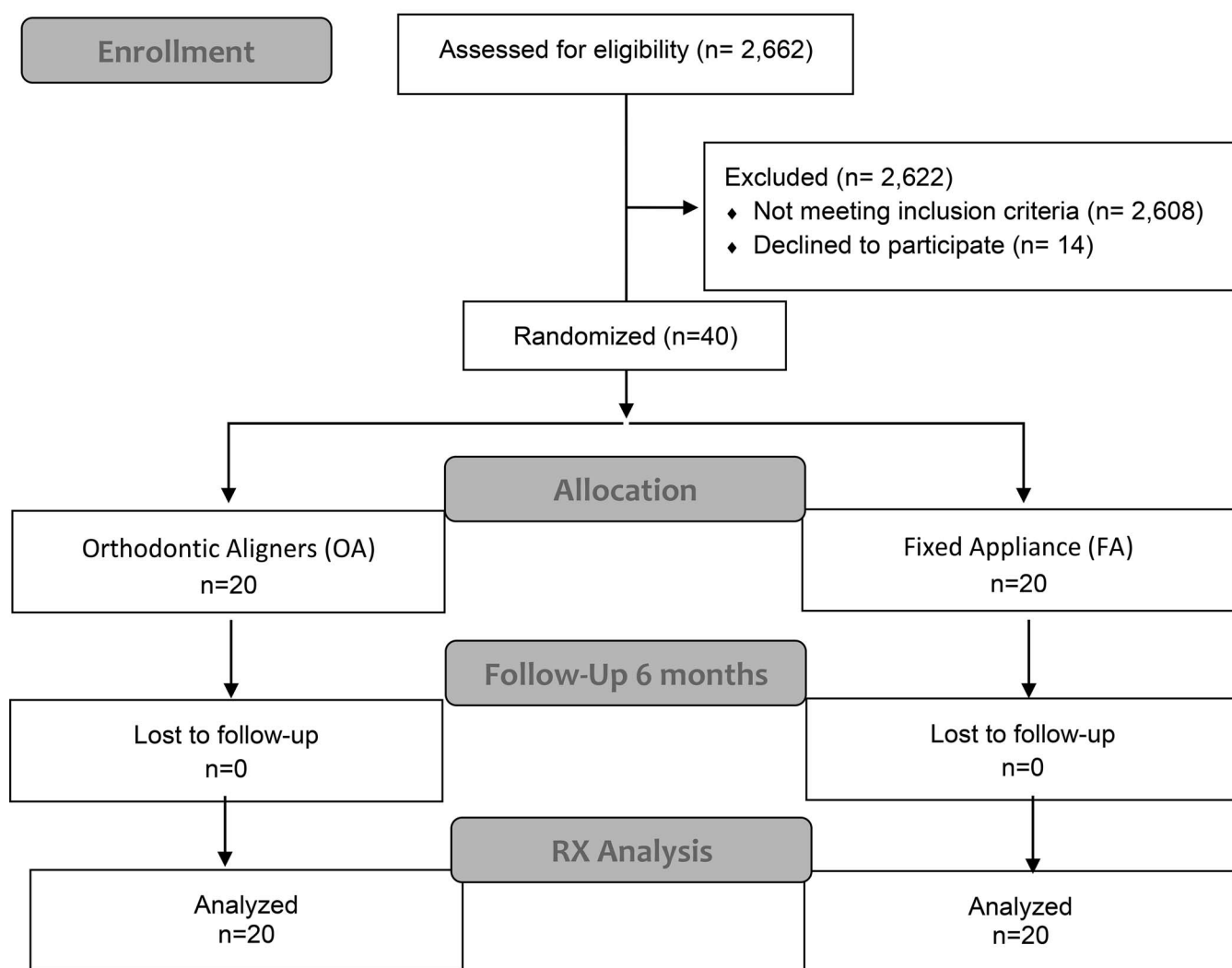
CONSORT 2010 Flow Diagram

Figure 1. Consolidated Standards of Reporting Trials (CONSORT) diagram showing the flow of patients through the trial.

ately after the aligners were inserted, pronunciation of the phoneme /ch/ was found to have a deeper, more prolonged sound in 50% of the patients and prolonged in 35%, while in the FA group, just 5% presented with intense pronunciation ($P < .001$). Three days after the start of treatment, 65% of patients in the OA group demonstrated prolonged pronunciation compared with 5% of patients in FA group ($P < .001$). At the 30-day ($P = .487$) and 180-day ($P = 1$) evaluations, the groups were found to be statistically similar (Table 3).

Table 1. Description of the Groups: Age, Sex, Degree of Crowding (Little's Irregularity Index), and Severity of Malocclusion (Peer Assessment Rating Index)[a]

Variables	OA (n = 20)	FA (n = 20)	P
Age (y), mean (SD)[b]	23.60 (5.65)	20.56 (4.51)	.0681
Sex[c]			
Male, n (%)	12 (60)	13 (65)	1.0000
Female, n (%)	8 (40)	7 (35)	
Peer Assessment Rating index, mean (SD)[b]	7.70 (4.66)	7.50 (3.18)	.8751
Little's Irregularity Index, mean (SD)[b]	4.69 (1.35)	4.99 (1.88)	.5705

[a] FA, fixed appliance; OA, orthodontic aligner; SD, standard deviation.
[b] Independent t test.
[c] χ^2 test with Yates correction.

During patient self-assessment of speech production, similar results were found between the groups at each time point of evaluation ($P > .05$). However, irrespective of the type of appliance used, patients perceived an alteration in speech immediately after insertion (T1) and 3 days after commencement of treatment (T2). Thirty days after treatment began, however, adaptation occurred, and the difference compared with the baseline evaluation (T0) was no longer significant (Table 4).

DISCUSSION

The use of orthodontic appliances may adversely affect dental anatomy, space in the oral cavity, movement of the tongue and perioral musculature, and, consequently, speech production. These changes should be considered by orthodontists and shared with patients.[12] Therefore, this randomized clinical study

Table 2. General Speech Alteration in the FA and OA Groups[a]

	General Speech Alteration			
Groups	No, n (%)	Yes, n (%)	Total, n (%)	P
Baseline				
FA	20 (100)	0 (0)	20 (100)	[b]
OA	20 (100)	0 (0)	20 (100)	
Immediately after				
FA	19 (95)	1 (5)	20 (100)	<.001*
OA	3 (15)	17 (85)	20 (100)	
3 days				
FA	19 (95)	1 (5)	20 (100)	<.001*
OA	8 (40)	12 (60)	20 (100)	
30 days				
FA	20 (100)	0 (0)	20 (100)	.487
OA	18 (90)	2 (10)	20 (100)	
180 days				
FA	20 (100)	0 (0)	20 (100)	[b]
OA	20 (100)	0 (0)	20 (100)	

[a] FA, fixed appliance; OA, orthodontic aligner.
[b] No statistics were computed because speech alteration is a constant.
* Statistically significant ($P < .05$); Fisher exact test.

Table 3. The /ch/ Sound Alteration in the FA and OA Groups[a]

	/ch/ Sound Alteration				
		Yes			
Groups	No, n (%)	Prolonged, n (%)	More Intense Prolonged, n (%)	Total, n (%)	P
Baseline					
FA	20 (100)	0 (0)	0 (0)	20 (100)	[b]
OA	20 (100)	0 (0)	0 (0)	20 (100)	
Immediately after					
FA	19 (95)	1 (5)	0 (0)	20 (100)	<.00[c]
OA	3 (15)	7 (35)	10 (50)	20 (100)	
3 days					
FA	19 (95)	1 (5)	0 (0)	20 (100)	<.001[d]
OA	7 (35)	13 (65)	0 (0)	20 (100)	
30 days					
FA	20 (100)	0 (0)	0 (0)	20 (100)	.487
OA	18 (90)	2 (10)	0 (0)	20 (100)	
180 days					
FA	20 (100)	0 (0)	0 (0)	20 (100)	[b]
OA	20 (100)	0 (0)	0 (0)	20 (100)	

[a] FA, fixed appliance; OA, orthodontic aligner.
[b] No statistics were computed because /ch/ sound is a constant.
[c] Statistically significant ($P < .05$); χ^2 test test.
[d] Statistically significant ($P < .05$); Fisher exact test.

was conducted on patients randomly assigned to treatment with OAs and FAs.

The analysis conducted by the speech therapist revealed a significant change in the production only in patients treated with OAs from immediately after insertion until the third day using the appliance. Based on the 30-day evaluation, no difference was evident between the groups. These results were probably due to the fact that the OAs, despite being relatively thin, partially changed the anatomy of the tooth surfaces and, consequently, the oral conditions required for speech production via the phonoarticulatory organs. For the correct production of specific speech sounds, there can be no interference between the hard and soft structures of the stomatognathic system. In the interval between the 30-day and 180-day evaluations, the patients undergoing treatment with OAs adapted. The short period of time needed for patients to adapt to OAs may be explained by the precise adjustment of the appliance to the palatal/lingual tooth surface.[6] In addition, the results of the present study were in agreement with Shalish et al.,[13] who evaluated the subjective perception of patients by means of a health-related quality of life instrument in the first week and after 14 days of treatment. They found that only a few days were needed for patients who immediately experienced difficulty in speaking to adapt to orthodontic treatment , irrespective of the type of appliance used.

The impairment of speech in patients undergoing orthodontic treatment only with OAs was also the

Table 4. Self-Assessment of Speech Production[a,b]

| | VAS | | | | | | | | | | | | | | | |
| | Baseline | | | Immediately After | | | 3 Days | | | 30 Days | | | 180 Days | | | P |
Group	Median	1st Quartile	3rd Quartile	Median	1st Quartile	3rd Quartile	Median	1st Quartile	3rd Quartile	Median	1st Q	3rd Q	Median	1st Q	3rd Q	(Between Times)
FA	0.0[x]	0.0	0.0	1.0[y]	0.0	4.0	1.0[y,z]	0.0	1.9	0.0[x,z]	0.0	1.6	0.0[x]	0.0	0.0	<.001*
OA	0.0[x]	0.0	0.0	1.5[y]	0.8	3.9	1.3[y]	0.1	1.7	0.0[x]	0.0	0.4	0.0[x]	0.0	0.0	<.001*
P (between groups)	1.000			0.301			0.414			0.820			0.820			

[a] FA, fixed appliance; OA, orthodontic aligner; VAS, visual analog scale.

[b] Comparisons between groups were performed using the Mann-Whitney test, and intragroup comparisons were performed using the Friedman test. Times with same letter have no statistically significant difference between them.

* Statistically significant ($P < .05$).

objective of another study.[6] Of the 54 patients who responded to the 12-item questionnaire in the third and sixth months after the start of treatment, 46.3% did not report any impairment, and 76% did not note any narrowing of the space for the tongue in the oral cavity. Although the evaluation was only based on patient responses, the time required for adaptation to aligners was 1 week for 84% of the patients and 2 weeks for 16% of patients. These results were in agreement with the semiobjective evaluation in this study.

On the other hand, Pogal-Sussman-Gandia et al.[7] stated that OAs would not be indicated for patients concerned about speech impairment, as the aligners affected the articulation of consonants, which could compromise the patient's adherence to treatment. However, that study was based on a single evaluation, with patients in a broad age group (14 to 62 years old), evaluated at different moments during orthodontic treatment. Accordingly, considering that the present study performed evaluations at different time points, the adaptation period observed may be considered acceptable, and the temporary alterations in speech production would not restrict the indication for treatment with OAs.[8,14]

The semiobjective (perceptive/auditive) evaluation carried out in this study demonstrated a significant change in speech production for the phoneme /ch/ only in patients treated with OAs, immediately and 3 days after insertion. Immediately after insertion of the appliances, 50% of patients in the OA group produced a more intense and prolonged phoneme sound, while 35% exhibited prolonged pronunciation. Three days after insertion of OAs, 65% of patients already exhibited prolonged pronunciation, which demonstrated the patient's swift adaptation to the appliance. The change in production of the phoneme /ch/ may have occurred because it is a phoneme that requires production of a column of air over the tongue brushing the dental arches. Since the aligner covered the buccal and lingual dental surfaces, an increase in pressure in the column of air could have been stimulated through a

sensorial change in the anterior third of the tongue in contact with the appliance.

Although the semiobjective evaluation did not detect changes in speech production in the FA group, the patients' self-assessment with regard to the difficulty of speech measured by the VAS revealed that patients in both groups reported a certain level of difficulty with speech immediately after insertion of the appliances and in the evaluation after 3 days. These results were in agreement with other studies in which researchers observed the need for a period of patient adaptation for speech production after insertion of fixed or removable orthodontic appliances.[6,8,13] For patients treated with FAs, the difficulty in speaking reported immediately after insertion of the appliance and at 3 days was probably due to the presence of a foreign body on the buccal surface of the teeth, which could have altered oral sensory perception and lip mobility. Regardless of the group, the sensory adaptation and adaptation of the mobility of the perioral musculature, in addition to the resolution of the signs and symptoms, may have contributed to the patients' adaptation,[6,14,15] so that the results at 30 and 180 days would be similar to those at baseline.

At the start of the study, the two groups were similar in terms of age, sex, amount of lower anterior crowding (Little's Index) and severity of malocclusion (Peer Assessment Rating index), important criteria with respect to characteristics of malocclusion and for permitting the evaluation of speech characteristics. The change in speech production observed during the semiobjective evaluation of the patients in the OA group and in the self-assessment of patients in the OA and FA groups was important for helping orthodontists understand the effects of treatment and for explain to their patients the possible speech changes and their duration.

It is important to advise patients planning to be treated with OAs that there will be a temporary limitation to speech production ability, which could be considered disadvantageous to people in professions

that require them to speak in public. However, such patients can be instructed to remove the device when they need to speak in public until they are better adapted. Additionally, it is important to point out that patients with other initial characteristics (age range or type of malocclusion) might take different amounts of time to adapt to orthodontic treatment, with OAs or FAs.

CONCLUSIONS

- Changes in speech production were identified by a speech therapist at the beginning of treatment in the OA group only.
- Patient self-assessments demonstrated that orthodontic treatment, regardless of the type of appliance used, interferes with self-perception of speech production.
- Orthodontists should advise patients that the potential changes in speech production are temporary and that adaptation will likely occur during the first month of treatment.

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