https://doi.org/10.23925/2176-2724.2021v33i4p729-740

ARTICLES

Ultrasonography of tongue movements in the assessment and therapy of anterior lisp: a case study

Ultrassonografia dos movimentos de língua na avaliação e terapia do ceceio anterior: um estudo de caso

Ecografía de los movimientos de la lengua en la evaluación y la terapia del ceceo anterior: un estudio de caso

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Abstract

Introduction: lisping is a type of speech disorder resulting from changes in orofacial structures. The auditory-perceptual methods of speech-language assessment can raise doubts as to the nature of the disorder and, therefore, instrumental assessments are recommended to obtain a more accurate diagnosis. Ultrasonography of tongue movements allows real-time visualization of tongue movement during speech and may contribute to speech therapy as visual biofeedback. **Objectives:** To describe the articulatory gestures of fricatives /s/, /z/, /ʃ/ e /ʒ/ before and after speech therapy with visual ultrasound biofeedback in a child with anterior lisp. **Methods:** Several aspects of the speech of an eight-year-old girl with previous lisp were evaluated, and ultrasound images were collected before and after 05 therapy sessions using

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Authors' contributions:
KCM: Study conception; Methodology; Data collection; Draft of the article;
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Received: 23/11/2020
Accepted: 18/07/2021

ultrasound as instrumental biofeedback. The images of the tongue in the production of sounds /s, z, ʃ, ʒ/ were compared before and after the speech therapy intervention. **Results:** Before treatment, the patient anteriorized without raising the tip of the tongue in /s/ and /z/; in /ʃ/ and /ʒ/ there was anteriorization of the articulation point, but without interposition. After speech therapy, he adjusted the articulation point and acquired tongue tip elevation in /s/ and /z/ and presented greater tongue constriction in /ʃ/ and /ʒ/. **Conclusion:** Ultrasonography proved to be important for the diagnosis and description of the previous lisp, and its use as biofeedback allowed a significant improvement in articulatory production due to its self-monitoring during speech, in a short period of care.

Keywords: Articulatory disorder; Speech therapy; Orofacial Motricity; Language; Ultrasonography.

Resumo

Introdução: O ceceio é um tipo de transtorno dos sons da fala decorrente de alterações nas estruturas orofaciais. Os métodos perceptivo-auditivos de avaliação fonoaudiológica podem gerar dúvidas quanto à natureza do transtorno e, portanto, as avaliações instrumentais são recomendadas para obter um diagnóstico mais preciso e completo. A ultrassonografia dos movimentos de língua permite a visualização em tempo real do movimento da língua durante a fala podendo contribuir na fonoterapia como *biofeedback* visual ultrassonográfico (BVU). **Objetivos:** Descrever os gestos articulatórios das fricativas /s/, /z/, /ʃ/ e /ʒ/ pré e pós-terapia fonoaudiológica com BVU em uma criança com ceceio anterior. **Métodos:** Foram avaliados diversos aspectos da fala de uma menina de oito anos com ceceio anterior, e coletadas imagens ultrassonográficas antes e após cinco sessões de terapia utilizando BVU. Foram comparadas as imagens da língua na produção dos sons /s, z, ʃ, ʒ/ pré e pós a intervenção fonoaudiológica com BVU. **Resultados:** Antes do tratamento, a paciente anteriorizava sem elevar a ponta de língua em /s/ e /z/; e em /ʃ/ e /ʒ/ também havia anteriorização de ponto articulatório, mas sem interposição. Após a fonoterapia, houve ajuste do ponto articulatório e aquisição da elevação de ponta de língua em /s/ e /z/ resultando em maior constrição de língua em /ʃ/ e /ʒ/. **Conclusão:** A ultrassonografia mostrou-se importante para a caracterização e descrição do ceceio anterior, e o seu uso como BVU permitiu melhora expressiva na produção articulatória por proporcionar automonitoramento durante a fala, num curto período de atendimento.

Palavras-chave: Transtorno articulatório; Terapia fonoaudiológica; Motricidade Orofacial; Linguagem; Ultrassonografia.

Resumen

Introducción: el ceceo es un tipo de trastorno del habla resultante de cambios en las estructuras orofaciales. Los métodos auditivo-perceptivos de evaluación del habla y el lenguaje pueden generar dudas sobre la naturaleza del trastorno y, por lo tanto, se recomiendan evaluaciones instrumentales para obtener un diagnóstico más preciso. La ecografía de los movimientos de la lengua permite la visualización en tiempo real del movimiento de la lengua durante el habla y puede contribuir a la terapia del habla como biorretroalimentación visual. **Objetivos:** Describir los gestos articulatorios involucrados en la producción del habla de un niño con ceceo previo y compararlos antes y después de la logopedia con biofeedback visual por ultrasonido. **Métodos:** Se evaluaron varios aspectos del habla de una niña de ocho años con ceceo previo, y se recolectaron imágenes de ultrasonido antes y después de 05 sesiones de terapia utilizando ultrasonido como biofeedback instrumental. Se compararon las imágenes de la lengua en la producción de sonidos /s, z, ʃ, ʒ/ antes y después de la intervención logopédica. **Resultados:** antes del tratamiento, el paciente realizó una anteriorización sin levantar la punta de la lengua en /s/ y /z/; en /ʃ/ y /ʒ/ hubo anteriorización del punto de articulación, pero sin interposición. Después de la logopedia, ajustó el punto de articulación y adquirió elevación de la punta de la lengua en /s/ y /z/ y presentó mayor constricción de la lengua en /ʃ/ y /ʒ/. **Conclusión:** La ecografía demostró ser importante para el diagnóstico y descripción del ceceo previo, y su uso como biofeedback permitió una mejora significativa en la producción articulatoria debido a su autocontrol durante el habla, en un corto período de atención.

Palabras clave: Trastorno articulatorio; Terapia del lenguaje; Motricidad orofacial; Idioma; Ecografía.

Introduction

Speech is an ability conditioned on the development and maturation of cognitive, linguistic, organic, and motor aspects. Therefore, for it to be intelligible, both the phonetic aspect (articulatory production) and the phonological aspect (organization of the sound system of the tongue) must be developed [1]. Relative to the phonetic aspect, some factors are determinant for the appropriate articulation of the sounds, among which some structures of the stomatognathic system (SS) stand out, such as the bones, muscles, teeth, lips, tongue, and cheeks. Furthermore, such structures of the SS are also responsible for the functions of breathing, resonance, suction, chewing, and swallowing [2].

Therefore, if the articulatory production depends on the structural conditions of the SS, i.e., the occlusion and the position and mobility of the tongue, lips, cheeks, and jaws, then the existence of structural and functional alterations of the SS may modify the airflow responsible for sound emission and cause speech alterations denominated articulatory disorders [1,3].

The term "Speech Sound Disorder (SSD)" is a generic term that refers to any difficulty or combination of difficulties with perception, motor production, and/or phonological representation of the sounds and segments of speech and may have an organic or functional nature [4]. For example, the altered tongue position on the vertical and antero-posterior planes, i.e., low tongue and tongue between the teeth, causes articulatory disorders such as anterior lisp (in the production of linguo-alveolar fricatives /s/ and /z/) or interdentalization (in the production of plosives /t/ and /d/ and nasal /n/) [3,5,6].

The articulatory gesture has a dynamic nature, which makes it so that adopting a dynamic model provides more significant subsidies to identify and interpret phonic contrasts that are not possible via auditory-perceptual analysis. It is observed that the articulatory gesture is defined in time and space, having "tract variables", i.e., of the articulators, dimensions of independent tasks that specify the goal of an articulatory gesture, and each tract variable is associated with a specific set of articulators [7]; such a model contemplates the description of the articulatory disorder - lisping.

Relative to the speech therapy treatment of articulatory disorders, the more usual approach is reeducation in orofacial motricity (OM), which consists of myofunctional exercises to increase muscle strength, cause changes to the functional patterns, and, in the case of treating children, prevent craniofacial development disorders, promoting new postures both at rest and upon the execution of stomatognathic functions [8]. For such, exercises of muscle tension adjustment, mobility, and postural awareness training of the altered SS structures are necessary.

Clinical interventions in OM are more successful when there are minimal recurrences and automation of the function, and, for such, short/medium term solutions must be proposed, as well as practices that enable home training and patient self-monitoring [9]. It is also indispensable that the speech therapist develops the patient's self-perception of their speech for the articulatory adjustments, leading them to contrast the presented deviations with the correct speech model.

However, one of the great difficulties in providing visual *feedback* that allows the patient to notice their speech alterations, fully visualize the production of the correct model, and keep the self-monitoring in existence because articulatory disorders are learned behaviors, often compensating a structural alteration, and end up being consolidated over time [9,10].

Given this difficulty, we stress the importance of using resources with *feedback* and visual clues, especially in the context of articulatory disorder therapy, in which articulatory skills are trained for speech production, aiming for their acquisition, retention, and generalization [11]. In this context, the acquisition of a skill is related to the increase in performance while speaking and may reflect a temporary improvement to speech and/or a more precise articulatory production while training the target sound during the therapy session. On the other hand, learning refers to relatively permanent changes, including retention and generalization to untrained tasks [11].

Hence, the acquisition is indispensable and is part of the therapeutic process; however, to automatize a skill, key aspects known as Principles of Motor Learning of Speech are necessary, which are based on the complexity of tasks, on a practice schedule, and in the provision of detailed responses (*feedback*) about the movements and performance of the patient in articulatory training [11]. With the purpose to find resources to apply the Principles of Motor Learning of Speech in articulatory disorder therapy more effectively, many speech therapists have researched the use of such principles associated with instrumental *biofeedback*, which comes from instruments commonly used to assess speech and voice that provide a sensory response (visual or auditory) to the patient [12–14].

Ultrasonography (USG) of tongue movements is one of the instrumental resources used for articulatory analysis. This use becomes frequent for offering countless benefits because it is a non-invasive technique relatively accessible relative to other diagnostic imaging methods, capable of generating a dynamic and anatomically precise image of the tongue surface with minimal interference in the visualization of intraoral movements.

Therefore, the USG of tongue movements provides the patient visual *feedback* about their result and articulatory performance in real-time, in addition to a precise and complementary analysis for the professional [12,15,16]. Despite its growing use in other areas of Speech Therapy, research on the use of USG in articulatory disorder therapy is still necessary and recommended, including the use of Ultrasound Visual *Biofeedback* (UVB) associated with the Principles of Motor Learning of Speech for treating such disorders.

Given the above, this article aims to describe the articulatory gestures of fricatives /s/, /z/, /ʃ/, and /ʒ/ before and after therapy with UVB for a child with anterior lisp.

Method

This is a clinical case study of quanti-qualitative nature carried out in a school clinic of a Speech Therapy program of a Higher Education Institution, duly registered with the Research Ethics Committee. The ethical guidelines and procedures for human research according to Resolution No. 466/12 of the Brazilian National Ethics Council were respected; hence, the person responsible for the patient signed the Free and Informed Consent Form, and the patient signed the Consent Form.

Case presentation

The eight-year-old patient in this study arrived at the said school clinic with complaints of speech alterations. Initially, anamnesis was performed with the patient's mother to observe possible relationships between the complaint and her clinical and developmental history. At that time, the patient's mother informed us about the presence of an oral habit (pacifier use) for a prolonged period, without specifying the duration. The child no longer used pacifiers at the time of the assessment. Hence, speech therapy assessments were carried out according to the complaint of speech alteration to assess aspects of language, orofacial motricity, and hearing, as well as an ultrasound assessment of the tongue movements. After the assessments, the child received speech therapy.

Assessments before the therapy

To assess language and speech, the following instruments were applied: the Phonological Assessment Instrument (INFONO) [17], the Child Naming Test (TIN) [18], the Receptive Auditory Vocabulary Test (TVAud-33) [19], the Proof of Phonological Awareness by Oral Production (PCFO) [20], and the Phonological Discrimination Test (TDF) [21]. The observational assessment of oral and written language was also carried out through spontaneous speech, conversation, and text reading.

During the spontaneous speech, the patient presented distortions in phonemes /s/ and /z/; however, in the phonological assessment (INFONO), no phonological exchanges represented by omission or substitution of sounds occurred, nor did articulatory distortions, demonstrating a self-monitoring on her part during the formal assessment. Relative to the other language assessments, the patient presented a favorable performance in both TIN and PCFO considering her age group, and she got 100% of the tasks right in TVAud-33 and TDF. The patient was attending the third year of primary school, and no learning difficulties were observed.

For the speech therapy assessment of orofacial motricity, the Orofacial Myofunctional Assessment with Scores (AMIOFE) [22] protocol was applied in full, in which case it was possible to detect orofacial myofunctional disorders such as tongue interposition only while speaking, with it not being present in the normal position, and decreased tongue tonus, without further myofunctional alterations.

Lastly, an audiological assessment (auditory triage) was carried out at the frequencies related to speech (500 Hz, 1 kHz, 2 kHz, 4 kHz, and 6 kHz), in which case the patient presented auditory thresholds within the normality standards in both ears.

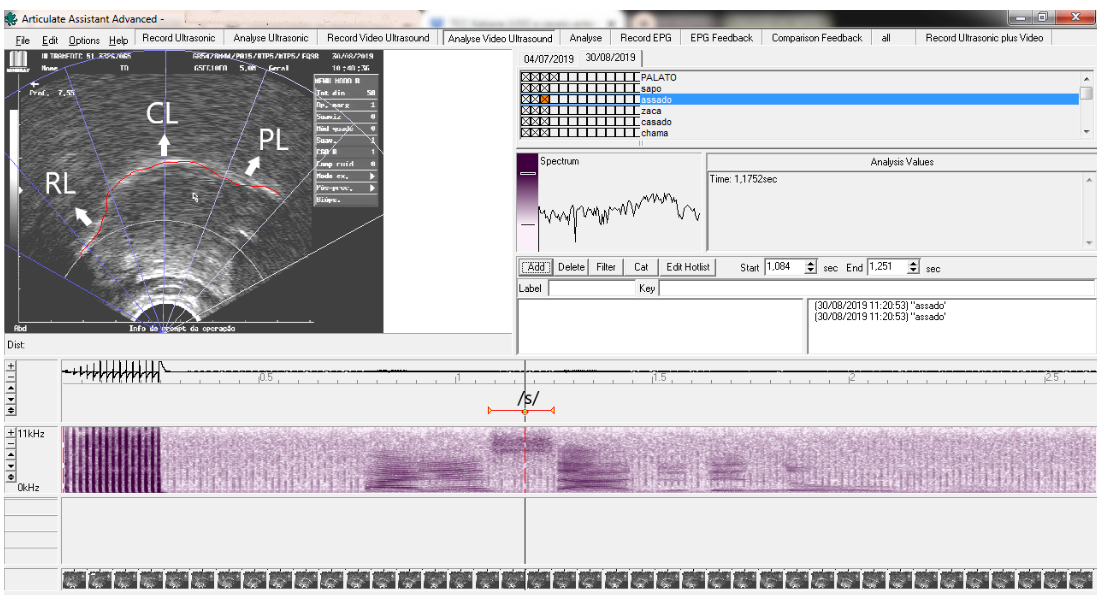
. For the procedure of ultrasonography (USG) assessment of the tongue movements, the software Articulate Assistant Advanced (AAA, Articulate

Instruments Ltd) was used, along with the following equipment: high-performance unidirectional microphone (Shure - SM48); portable ultrasound (Mindray - DP6600) on which an endocavitary transducer (65C10EA) was connected, placed fixedly at the submandibular region, attached to the head stabilizer (Articulate Instruments Ltd); BrightSync synchronizer; soundbox; and a computer with two monitors (one for recording and the other for displaying the figures for naming).

The USG was performed with the application of the Protocol for Instrumental Speech Assessment (PRAINF) [23] to observe the articulatory gestures during the production of each consonant phoneme. In this assessment, alterations to the vertical and anteroposterior planes of the tongue during the production of the lingo-alveolar fricatives /s, z/ and palatal fricatives /ʃ, ʒ/ were observed, besides inappropriate constriction. Hence, another ultrasound assessment was carried out with a *corpus* of twenty-four words from Brazilian Portuguese containing only fricative phonemes /s, z, ʃ, ʒ/ preceding vowels /a, i, u/ in the two positions: Initial *Onset* (IO) and Medial *Onset* (MO).

Before collecting the speech sample, the patient was asked to fill the oral cavity with water for observing and delimiting the hard palate. All the words, besides the PRAINF, were represented by figures and presented through the computer screen for naming. The patient was instructed to speak the target word inserted in the vehicle sentence "Say [word] again", naming the figures in the typical vocal pattern (intensity, frequency, and speed). During the recording, the participant remained comfortably seated inside an acoustic enclosure.

The tongue constriction images were analyzed through an outline over the tongue surface (in a sagittal cut) at the instant corresponding to the middle point of the consonant, based on the spectrogram provided by the program (Figure 1).



Caption: PL = Tongue tip; CL = Tongue body; RL = Tongue root..

Figure 1. The window of the software Articulate Assistant Advanced showing the ultrasound image of the tongue during the production of the fricative /s/

The articulatory analysis of the data collected with the USG was carried out using the *Workspace* tool of the AAA *software*. The tongue image interpretation was based on the gesture descriptors proposed by Gesture Phonology, i.e., on the tract variables that correspond to the constriction actions of the vocal tract organs and their reference with the involved articulators: tongue tip constriction location (TTCL), tongue tip constriction degree (TTCD), tongue body constriction location (TBCL), and tongue body constriction degree (TBCD) [7] (Chart 1).

Chart 1. Descriptors proposed by FonGest for the fricatives /s, z/ and /ʃ, ʒ/

Phonemes	Articulators involved	Constriction degree and site
/s/	Tongue tip	Critical, alveolar
	Tongue body	Critical, palatal
	Velum	Closed, pharyngeal
	Glottis	Wide
/z/	Tongue tip	Critical, alveolar
	Tongue body	Critical, palatal
	Velum	Closed, pharyngeal
	Glottis	Narrow
/ʃ/	Tongue tip	Critical, post-alveolar
	Tongue body	Critical, palatal and pharyngeal
	Velum	Closed, pharyngeal
	Glottis	Wide
/ʒ/	Tongue tip	Critical, post-alveolar
	Tongue body	Critical, palatal and pharyngeal
	Velum	Closed, pharyngeal
	Glottis	Narrow

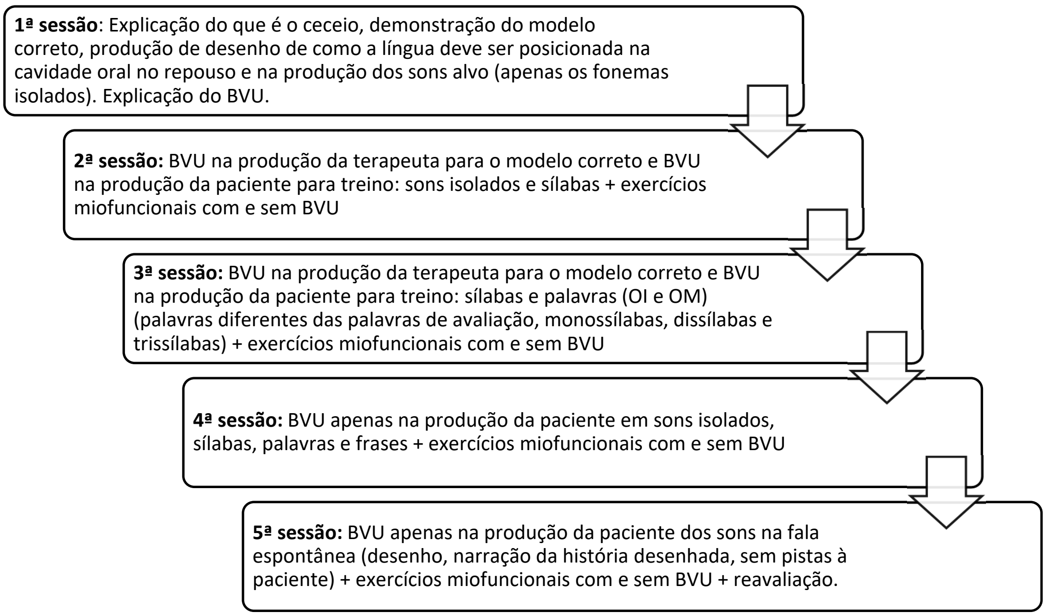
From the results of the assessments, it was determined that the patient had an articulatory disorder of the anterior lisp type and, therefore, received specific clinical intervention for treating the anterior lisp with additional opportunities to practice the precise production with and without UVB.

Clinical Intervention

Five treatment sessions were held once a week with duration of fifty minutes each, totalizing five weeks. The treatment sessions were conducted individually by a second author, a doctoral student speech therapist with experience in assessment and therapy with UVB.

The UVB was offered through the same portable ultrasound used in the assessment. However, the therapy sessions were held outside the acoustic enclosure and without a head-stabilizing helmet so to enable the UVB dynamic with the model of the patient and the therapist.

The structure of the sessions, including the complexity of the worked stimuli and the training schedule, is exposed in Figure 2.



Caption: UVB = Ultrasound Visual Biofeedback; IO = Initial Onset; MO = Medial Onset.

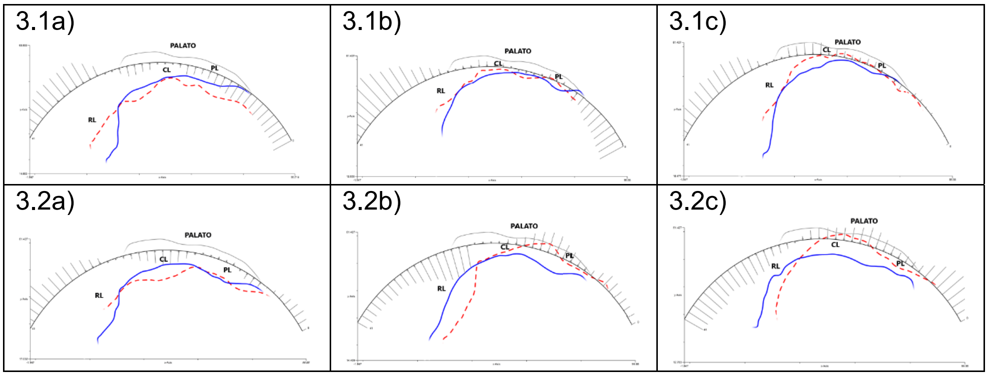
Figure 2. Structure of the speech therapy sessions following the Principles of Motor Learning of Speech with and without UVB.

The first session was introduced by making the patient aware of the articulatory disorder, more specifically the anterior lisp, in the presence of her mother so that the mother learned of the disorder and the results obtained and could then reinforce the information in the family environment. In the following sessions, the patient had the UVB and oral *feedback* from the therapist and was asked to produce sounds, syllables, words, sentences, and, lastly, spontaneous speech. In addition to the production training, the patient carried out myofunctional exercises of tongue tension and mobility daily. In the fourth session, the patient relied only on the UVB during the spontaneous speech, with *feedback* and clues from the therapist no longer being necessary. In the fifth session, the reassessment was carried out through USG with twenty-four words containing the sounds /s, z, ʃ, and ʒ/.

Results

Articulatory data from the USG

One may observe in Figure 3 the tongue images referring to the tongue contour at the point of maximum constriction of the production of the fricative /s/.



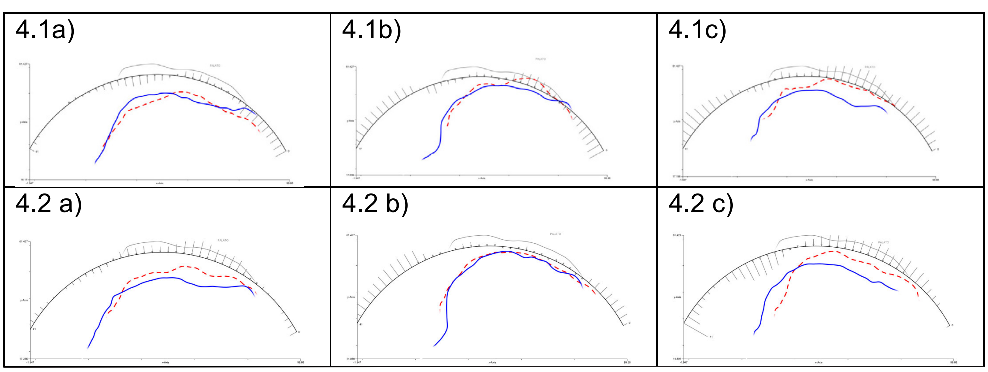
Caption: RL = tongue root; CL = tongue body; PL = tongue tip; dashed line = pre-therapy; continuous line = post-therapy; down arrows = indicating a lowering of the tongue region; up arrows = indicate an elevation of the tongue region; 0 = axis zero of the fan spline; 41 = axis 41 of the fan spline.
Statistically significant differences (T-test level 5%)

Figure 3. Average contours of the tongue surface of the fricative /s/ in the Initial Onset (3.1) and Medial Onset (3.2) positions. a) /s/ preceding the vowel /a/; b) /s/ preceding the vowel /i/; c) /s/ preceding the vowel /u/.

Before the therapy, as per the FonGest descriptors, one may observe quite an irregular tongue contour in all vocalic contexts and positions. The alteration of the TTCL (dental) in /i/ and /u/ in both the IO and MO is made evident, and one may also observe an alteration to the TBCD (tendency to closed) and the TBCL (post-alveolar). In the vocalic context, for /i/ and /u/ in the MO, there is a slight constriction in the CL towards the pharynx, which causes greater anteriorization in the entire extent of the tongue.

After the therapy, one may observe an adjustment of the articulators relative to both the degree and location of constriction in all contexts: critical TTCD and alveolar TTCL, and critical TBCD and palatal TBCL.

One may observe in Figure 4 the tongue images referring to the tongue contour at the point of maximum constriction of the production of the fricative /z/.



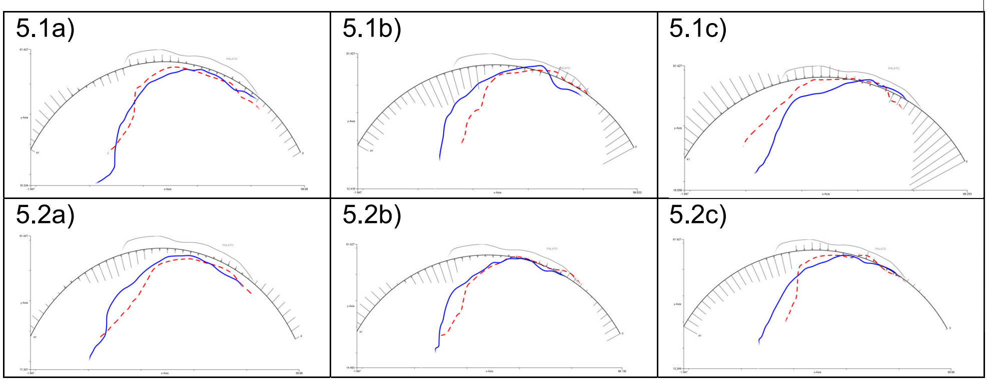
Caption: dashed line = pre-therapy; continuous line = post-therapy; down arrows = indicating a lowering of the tongue region; up arrows = indicate an elevation of the tongue region; 0 = axis zero of the fan spline; 41 = axis 41 of the fan spline.
Statistically significant differences (T-test level 5%)

Figure 4. Average contours of the tongue surface of the fricative /z/ in the Initial Onset (4.1) and Medial Onset (4.2) positions. a) /z/ preceding the vowel /a/; b) /z/ preceding the vowel /i/; c) /z/ preceding the vowel /u/.

Before the therapy, as per the FonGest descriptors, one may observe a discretely irregular tongue contour in all the contexts. Especially in the vowel /a/ in the IO and the vowels /i/ and /u/ in the MO, alterations to the TTCL (dental) and the TBCL (post-alveolar) are observed. In the vocalic context, for /u/ in the MO, there is also a slight constriction in the CL towards the pharynx, which causes greater anteriorization in the entire extent of the tongue. Except for the vocalic context for /i/, where the TBCD tends to be closed, the TBCD and the TTCD are critical in the other contexts.

After the therapy, one may observe a more regular contour of the tongue surface and an adjustment of the articulators relative to both the degree and location of constriction: critical TBCD and palatal TBCL, and critical TTCD and alveolar TBCL.

One may observe in Figure 5 the tongue images referring to the tongue contour at the point of maximum constriction of the production of the fricative /ʃ/.



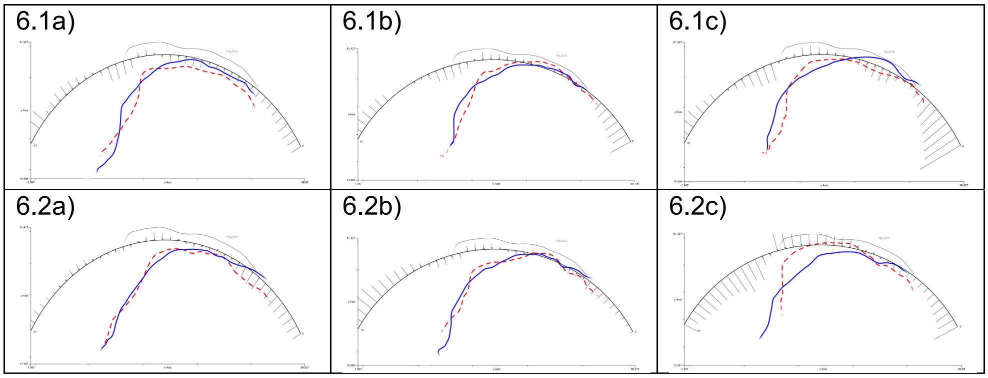
Caption: dashed line = pre-therapy; continuous line = post-therapy; down arrows = indicating a lowering of the tongue region; up arrows = indicate an elevation of the tongue region; 0 = axis zero of the fan spline; 41 = axis 41 of the fan spline. Statistically significant differences (T-test level 5%)

Figure 5. Average contours of the tongue surface of the fricative /ʃ/ in the Initial Onset (5.1) and Medial Onset (5.2) positions. a) /ʃ/ preceding the vowel /a/; b) /ʃ/ preceding the vowel /i/; c) /ʃ/ preceding the vowel /u/.

Before the therapy, one may observe an adjustment in the TBCL (palatal) and alterations regarding the TTCL: in /a/ (dental) and in /i/ and /u/ (alveolar). Relative to the TTCD and the TBCD, both are critical.

After the therapy, there was an adjustment in the TBCL, which became pharyngeal and palatal, and the post-alveolar TTCL in /u/ in the IO and /i/ in the MO. Although there was an improvement in the articulatory gesture, especially in the tongue contour, the complete adjustment of the TTCL in the other contexts is not observed, remaining alveolar.

One may observe in Figure 6 the tongue images referring to the tongue contour at the point of maximum constriction of the production of the fricative /ʒ/.



Caption: dashed line = pre-therapy; continuous line = post-therapy; down arrows = indicating a lowering of the tongue region; up arrows = indicate an elevation of the tongue region; 0 = axis zero of the fan spline; 41 = axis 41 of the fan spline.
Statistically significant differences (T-test level 5%)

Figure 6. Average contours of the tongue surface of the fricative /ʒ/ in the Initial Onset (6.1) and Medial Onset (6.2) positions. a) /ʒ/ preceding the vowel /a/; b) /ʒ/ preceding the vowel /i/; c) /ʒ/ preceding the vowel /u/.

Before the therapy, it was possible to observe alterations in the TTCL (dental), the TBCL (post-alveolar), and the magnitude of the TTCD and the TBCL. For /u/ in the MO, a tendency to be closed is observed in the TBCD. After the therapy, one may observe an improvement in the TTCL, becoming alveolar, which does not indicate complete adjustment. Relative to the TBCL, there was no modification. Regarding the TTCD and the TBCD, both proved to be appropriate.

Discussion

The tongue contours differ in their extensions for the production of each one of the phonemes. To produce the pair /s, z/, a narrowing of the air passage until its turbulence point in the constriction of the tongue tip at the alveolar region is necessary, while the tongue body presents a greater upward inclination to produce the pair /ʃ, ʒ/, with there being a constriction from the tongue root region (pharyngeal TBCL), with the air being quickly conducted to its turbulence point in the constriction of the tongue body (palatal and pharyngeal TBCL) and tongue tip (post-alveolar TTCL) [24].

Hence, according to FonGest, in a typical articulatory production, the phoneme pairs /s, z/ and /ʃ, ʒ/ become equal relative to the TTCD and the TBCD, with both being critical, and become different relative to the TTCL and the TBCL because /ʃ, ʒ/ have a more significant elevation of the tongue body and contraction towards the palatal region and also towards the pharynx, in addition to more considerable vibration during the movement, which does not occur with the pair /s, z/ [25]. In anterior lisping, the degree of constriction remains critical, yet the constriction location is altered, with the tongue body and tip being anteriorized relative to the alveoli, i.e., in the production of the pair /s, z/, the TTCL is dental, while the TBCL is post-alveolar in the production of /ʃ, ʒ/.

The intervention with UVB associated with the Principles of Motor Learning of Speech and the myofunctional approach proved to be effective in the therapy of this patient with an anterior lisp, which agrees with the literature findings mentioned herein. Relative to the myofunctional approach in treating lisping, a study verified its efficiency and determined that it may bring many benefits, adjusting the phonological system concomitantly, although the intervention time varies among patients [1]. Moreover, some studies on using UVB during motor training of speech applying the Principles of Motor Learning of Speech verified that using this feedback was quite favorable to the acquisition and mastery of the trained abilities [11,26].

One of the aspects described in such studies is the complexity of the target sounds, which must be increasing and in accordance with the difficulty level of the patient, starting from less complex sound units to the more complex sound units: phoneme, syllable, word, phrases, and, lastly, spontaneous speech, as per the patient's performance.

This complexity hierarchy favors the stimulus chain, making it so that the articulation difficulties between the sounds are remedied because the smaller units trained beforehand are within larger units (words, sentences, and spontaneous speech) [11].

Another aspect to be considered is the establishment of a practice schedule: the training must have continuity and plenty of repetitions for each trained ability until it is acquired, and, in the end, abilities in different complexity degrees must be included in the training for motor learning to be established [11].

Besides the complexity of the target sounds and the practice schedule in the speech therapy, it is also important to stress that, at the time of the acquisition of the ability, i.e., during the training of the articulatory point, the *feedback* must be rich in details about the movements and one's performance in them. Once the ability is acquired and the goal is to consolidate it, establishing the motor learning, the feedback becomes less specific and starts to take the form of correction or positive reinforcement about the movement immediately. According to the patient's evolution, the clues and frequency of this therapist feedback decrease so that patient is capable of monitoring themselves.

A systematic literature review [27] analyzed a large variety of SSDs and therapy with UVB. A great variety of approaches using USG was observed. Some used USG in a manner complementary to the treatment, some in alternated periods within an intervention session [28]. Others used it in a gradually decreasing manner determined by the participant's progress [29], and others still used USG but not in all sessions [30]. This renders it difficult to state that the positive results of the treatment were due exclusively to the use of USG.

The study concluded that USG may be effective when used at the initial stages of motor learning but may be less effective in promoting sound generalization. Therefore, more robust studies that obey some criteria are necessary for the statements to be reliable.

Despite the benefits provided by therapy with UVB, the studies applying this resource to the treatment of articulatory disorders such as lisping are scarce. Such disorders are predominantly treated with myofunctional therapy, essentially offering the auditory feedback of the therapist about the movements of the articulators to the patients.

Relative to the study limitations, one may mention the lack of surveys (at the beginning and end of each therapeutic session) and that an assessment for observing the retention of the worked abilities was not carried out. Moreover, although improvement for /ʃ, ʒ/ was observed, possibly due to the execution of myofunctional exercises and the stimulation of phono-articulatory abilities, the patient did not adjust the articulatory gesture for these phonemes because this pair of fricatives was not worked specifically. It is important to observe that this study was not structured so to allow the systematic comparison of the efficacy of UVB but only to verify the therapeutic responses for one case of articulatory disorder. Future research is necessary to document the effects of UVB and compare the interventions with and without other types of *biofeedback*.

Hence, this therapy proposal for anterior lisp proved to be efficient considering the duration of the treatment and the obtained results. The importance of employing the Principles of Motor Learning of Speech was made evident, as well as of developing the patient's self-perception of their own speech through facilitating what the UVB promotes, meeting the challenge of the visualization of the tongue in motion in the oral cavity by the therapist and the patient.

We suggest that future studies be carried out with this intervention containing a more significant number of subjects and verifying results in groups with different types of feedback (for example, three groups: group I: traditional (without UVB) and without the structured application of the Principles of Motor Learning of Speech, group II: traditional with the structured application of the Principles of Motor Learning of Speech, group III: UVB with the structured application of the Principles of Motor Learning of Speech), and that surveys be conducted in each session since this study did not have such data.

Conclusion

After the five therapeutic sessions that included the employment of myofunctional exercises, the Principles of Motor Learning of Speech, and UVB, the patient acquired a tongue tip elevation in the lingo-alveolar fricatives /s, z/, adjusting the TBCL and the TTCL, and presented better tongue constriction in the palatal fricatives /ʃ, ʒ/. Hence, the USG of the tongue movements proved to be effective in diagnosing and describing the articulatory gestures before and after therapy through FonGest, which allows clear visualization of the evolution.

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