Case report

Effects of transcranial direct current stimulation (tDCS) on speech and quality of life of a total glossectomy patient: a case report

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ABSTRACT | INTRODUCTION: The tongue is essential for maintaining speech and swallowing, articulating vowels and consonants, and manipulating and ejecting the food bolus. Studies indicate that speech-language rehabilitation improves speech intelligibility by 18 to 42% in individuals who have undergone total glossectomy. Non-invasive brain stimulation techniques have been developed to promote neuroplasticity. Transcranial direct current stimulation (tDCS) applies low-intensity, safe, painless electrical stimulation, targeting neuronal excitability (anodal electrode) and hyperpolarization of the membrane potential (cathodal electrode). No study has addressed its effectiveness after treatment for head and neck cancer. **OBJECTIVE:** To evaluate the impact of tDCS associated with myofunctional exercises and articulatory compensation training on speech intelligibility and quality of life specifically regarding speech and swallowing in a total glossectomized subject previously submitted to speech-language therapy. **METHODS:** This exploratory, prospective, observational case report approached a total glossectomy participant previously submitted to traditional speech-language therapy for speech and swallowing rehabilitation. She underwent 14 sessions over 40 days, associating myofunctional exercises, articulatory training, and tDCS. The anodal electrode was positioned in the primary motor cortex (C3) and the cathodal electrode, in the right supraorbital region (Fp2), according to the International 10-20 System, providing 2 mA electrical stimuli for 20 minutes. The following instruments were applied on the 1st, 10th, and 14th days: Percentage of Consonants Correct (PCC), MD Anderson Dysphagia Questionnaire (MDADI), Speech Handicap Index (SHI), and auditory-perceptual evaluation based on automatisms, spontaneous speech, and naming through the phonological competence of the Child Language Test (ABFW). **RESULTS:** In the PCC naming domain, there was a 7% increase at the end of the intervention and an evolution from 96% to 99.2% in spontaneous speech. The participant acquired the precise production of unrounded vowels, consolidated the adequate compensation of the /k/, /z/, and /l/ phonemes, and reduced the omissions of the /r/ consonant group when produced in simple and complex onset. The SHI decreased from 37 points and self-assessed "average" speech before tDCS to 24 after 10 days of application and 31 at the end, with self-reported “good” speech quality on the 10th and 14th days of intervention. The MDADI score evolved from 48 points on day 1 to 63 points at the end of the study. **CONCLUSION:** The tDCS associated with myofunctional exercises and articulatory compensation training improved the speech-related quality of life, increased the PCC, and reduced the substitutions and omissions in speech. The improvements remained up to 30 days after the end of the intensive intervention. Moreover, the impact of dysphagia on the subject's quality of life decreased after the intervention.

KEYWORDS: Glossectomy. Speech. Transcranial Direct Current Stimulation.

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1. Introduction

Oral cavity cancer is the most prevalent malignancy among head and neck tumors.[1] According to data from the Brazilian National Cancer Institute (INCA)[2], 15,100 new cases are estimated for the next three years (2023-2025), mainly affecting males. Risk factors include smoking, alcoholism, and human papillomavirus.[3] Despite technological advances, these patients' 5-year survival rate is 63% in developing countries.[4] The treatment for tongue lesions depends on their stage and location, allowing for partial or total surgical procedure and/or adjuvant treatment, considering resection margins and quality of life.[5]

The tongue is essential for maintaining speech and swallowing, articulating vowels and consonants, and manipulating and ejecting the food bolus.[6]In some cases, it is possible to reconstruct the structure with microsurgical flaps, providing better feeding performance, airway protection, and speech optimization.[7,8]

Few and heterogeneous studies in the literature have described speech-language (SL) intervention in glossectomized patients' speech and swallowing, making evidence-based practice difficult.[9] The systematic review by Blyth et al.[9] found that myofunctional exercises and postural maneuvers were applied through clinical and instrumental evaluation throughout swallowing rehabilitation interventions.[10-13] As for communication, the data report articulation training for structural compensations during speech and the development of compensatory patterns.[13-16]

Studies indicate that SL rehabilitation improved speech intelligibility by 24 to 46% and 18 to 42% in individuals submitted to partial and total glossectomy, respectively.[16]

No previous study has approached glossectomized patients. However, recent research indicates positive results analyzing the effects of transcranial stimulation on sensorimotor learning[17], speech motor planning[18], neuroplasticity[19-21], and rehabilitation of dysarthrophonia and apraxia of speech in post-stroke patients.[22,23]

This relatively low-cost and easy-to-apply technique requires the application device, sponges, electrodes, and saline solution.[24,25] Recent studies have shown improved articulatory production after speech therapy intervention in individuals with neurological disorders and consequent speech disorders.[26]

Hashemirad et al.[17] applied anodal stimulation in the primary motor cortex (C3) and verified the possibility of favoring sensorimotor learning. Similarly, Lametti et al.[18] demonstrated, through tDCS, satisfactory development of previously acquired patterns related to speech learning. Guedes et al.[27] mapped the activation of cortical areas related to motor learning during saliva swallowing in postoperative glossectomized patients, evidencing the possibility of stimulating and, eventually, favoring neuroplasticity in these brain areas.

To our knowledge, few studies have addressed speech intelligibility and its possible interventions in glossectomized subjects[9], and none has approached its effectiveness after treatment for head and neck cancer.

2. Objectives

To evaluate the impact of applying transcranial direct current stimulation (tDCS) associated with myofunctional exercises and articulatory compensation training on speech intelligibility and quality of life specifically regarding speech and swallowing in a total glossectomized subject previously submitted to SL therapy.

3. Methodology

This is an exploratory, prospective, observational case report of a patient previously submitted to the traditional SL rehabilitation program for speech and swallowing at the SL Department of the A.C. Camargo Cancer Center. The study was carried out after the Research Ethics Committee had approved it (CAAE: 68343423.0.0000.5432; evaluation report no. 6.212.11) and the participant had signed an informed consent form.

Relevant clinical information was collected from the institutional electronic medical record and the previously performed SL intervention. The following instruments were applied on the 1st (day 1), 10th (day 10), and 14th day (day 14) of the study intervention:

• Speech Handicap Index (SHI):[28] This translated and culturally adapted protocol assesses the speech-related quality of life of subjects treated for head and neck cancer.[29] The final score is calculated by adding the questions in each domain – higher scores indicate worse speech-related quality of life.

• MD Anderson Dysphagia Questionnaire (MDADI):[30,31] Developed to measure the impact of dysphagia on the quality of life of individuals treated for head and neck cancer. Each domain's score is obtained by adding the values attributed to their respective questions, dividing by the number of questions, and multiplying by 20. The global question score ranges from 20 (extremely low functioning) to 100 (normal functioning). The total score is the average of the domains multiplied by 20. Hence, 0-20 is considered profound limitation; 21-40: severe limitation; 41-60: moderate limitation; 61-80: average limitation; 81-100: minimal limitation.

• Auditory-perceptual evaluation of speech: The patient's oral cavity was filmed with an electronic recording device (iPad) during spontaneous speech, having been asked to describe any family information that they wished to share to compose the speech sample, as well as counting from 1 to 20 and emitting the syllabic sequences: /pa ta ka/, /fi si chi/, /ta da na/, /la ra Ra/, and /ma nã nhã/. We also assessed speech disorders through figure naming in the phonological competence of the Child Language Test (ABFW).[32] This instrument is widely used in Brazilian clinical practice and research to assess the areas involved in communication: phonology, vocabulary, fluency, and pragmatics.[33]

• Percentage of Consonants Correct (PCC):[34] It aims to verify and quantify (mild, mild-moderate, moderate-severe, and severe) any disorder in the subject's speech.[35] The percentage is calculated by dividing the correct consonants by the total number of consonants that make up the sample and multiplying by 100. Errors are defined as moments when a consonant that should be produced is omitted, substituted, distorted, or added.[36]

The participant underwent brief intensive SL monitoring for 10 days, distributed equally over two weeks, allowing for a two-day break. Then there was another intervention once a week, over 4 weeks, totaling 14 sessions.

The intervention comprised exercises based on scientific evidence, following the institution's current rehabilitation routine, according to the therapeutic need and goal, aiming at speech rehabilitation, as follows: oral sensory stimulation, semi-occluded straw sucking, lip resistance on the spatula, oral flow training, and isolated and slow phoneme articulation training, gradually improving the speed and associating it with vowels.

A therapeutic plan was developed to systematize and adapt the exercises throughout the application, correlating phonological changes with their respective compensatory training and appropriate myofunctional exercises. As this is a recent science, most techniques used in patients after glossectomy, even in conventional therapy, do not have a consensus in the literature.9 One of the few studies related to the effectiveness of speech therapy after total glossectomy was developed at the originating institution.[13]

Electrical stimuli (2 mA) were applied during the SL intervention, positioning the anodic electrode (3,7 x 6,0 cm) in the topography corresponding to the primary motor cortex (C3) and the cathodic electrode (3,7 x 6,0 cm) in the right supra-orbital region (Fp2), both in portrait position, immersed in saline solution and secured with kinesiology tapes, according to the International 10-20 System.[37] The tDCS stimulation was applied for 20 minutes[18] by the Institution's SL pathologists, trained and certified to apply this technique.

The collected data were tabulated and analyzed by correlating the PCC, MDADI, and SHI scores before and after the intervention to indicate the impact of using the tDCS associated with conventional therapy.

4. Results

This case report applied tDCS to a 42-year-old female, a communication professional, diagnosed with adenoid cystic carcinoma. She underwent total glossectomy in November 2021, with microsurgical reconstruction of a right rectus abdominis flap, associated with bilateral cervical dissection levels I, IIa, and III, requiring tracheostomy and a nasogastric tube.

She underwent immediate postoperative SL monitoring for speech and swallowing rehabilitation, totaling 45 outpatient sessions over 23 months. They included traditional therapy with myofunctional exercises, articulatory training, and the development of compensatory patterns. During this period, she required adjuvant radiotherapy (IMRT SMART 30fx, with 60 Gy in the tumor bed and 54 Gy in the cervicofacial region and skull base) and surgical reapproach (fat grafting performed on May 31, 2023) to close a fistula in the oral cavity. Until the time of the tDCS intervention, she remained in weekly SL monitoring with traditional therapy.[13-16]

The study subject assiduously performed the proposed exercises and followed the SL guidelines throughout the previous rehabilitation. Despite the advances in speech intelligibility with conventional therapy, she complained of difficulty in being understood, pain in the temporomandibular joint (TMJ) region after long periods of speaking (she scored 5/5 on the intensity domain of the McGill Pain Questionnaire)[38], dissatisfaction with her speech intelligibility, and difficulty ingesting solid foods.

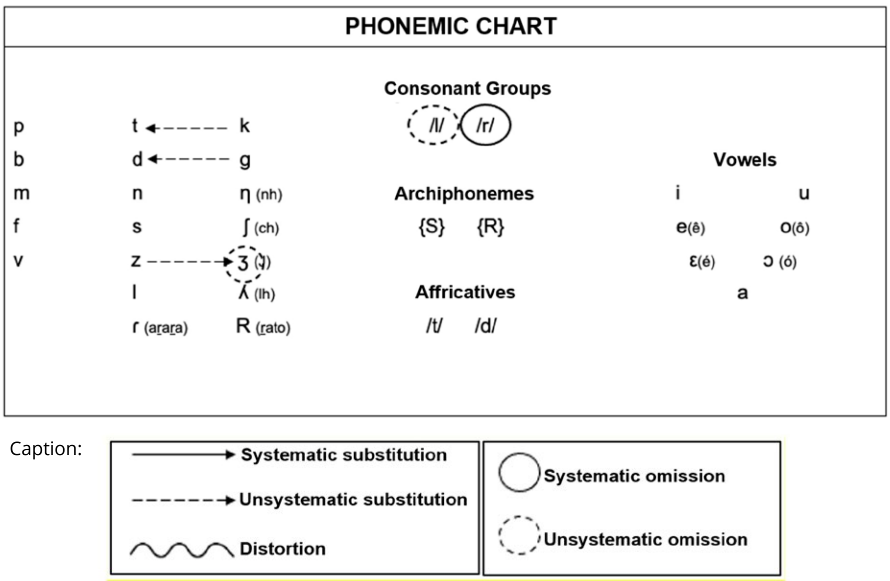
The assessment prior to the tDCS application found difficulty in producing the velar segments /k/ and /g/, substitution of the voiced alveolar fricative /z/ for the voiced post-alveolar /ʒ/, and unsystematic and systematic omission of the /l/ and /r/ consonant groups, respectively. The substitution of /z/ for /ʒ/ occurred due to anteriorization and compensation with the orbicularis oris muscle during the vocalization of unrounded vowels (/a/, /e/, and /i/).

Oral sensory stimulation was performed to promote oral proprioception, followed by myofunctional exercises to strengthen the buccinator and orbicularis oris muscles, and articulatory training with the altered phoneme in isolation, progressing with the association of vowels and a gradual increase in speed according to the adequate production of the segment, providing greater speech intelligibility and a decrease in inadequate compensations. This intervention decreased the TMJ pain, scoring 0/5 in the intensity domain of the McGill Pain Questionnaire.[38]

The phonological framework constructed from applying the ABFW naming domain shows the consolidated production of certain phonological segments and the interruption of certain substitutions in speech, as seen in the comparison between Figures 1 and 2. The anteriorized production of unrounded vowels became noticeable, requiring proprioceptive training for better conformity during speech.

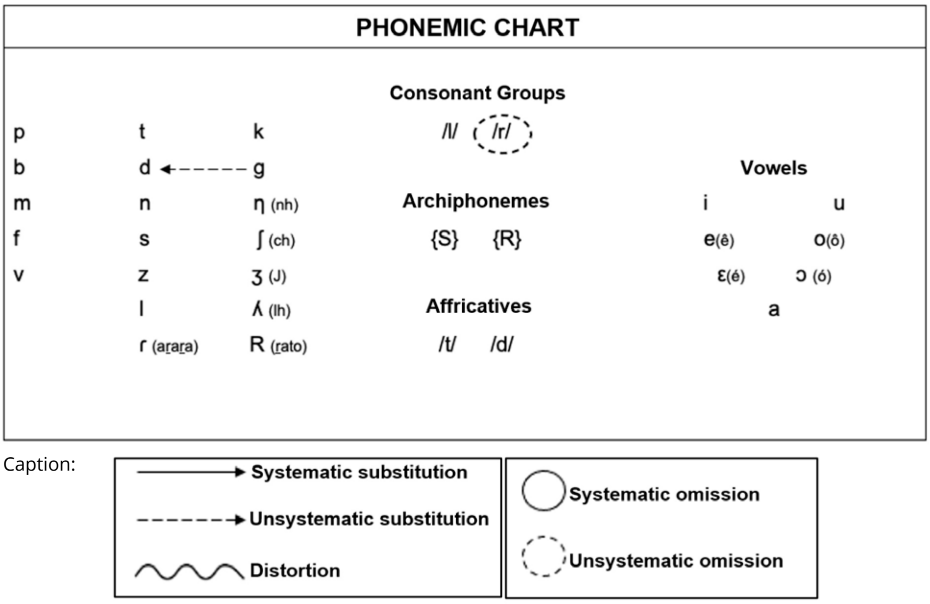
The participant reported a headache after the application in the first week of intervention, which ceased after maximizing the sleep periods, as the participant was under sleep deprivation for personal reasons. In the other applications, only itching was observed, allowing the study to continue with good tolerance to tDCS.

Figure 1. Phonemic chart on day 1 (assessment)



Source: the authors (2024).

Figure 2. Phonemic chart on days 10 (end of the 2 weeks) and 14 (end of weaning)



Source: the authors (2024).

The PCC improved, as described in Table 1, with a 7% increase in the ABFW domain at the end of the intervention.

Table 1. Percentage of Consonants Correct (PCC), based on the collected ABFW speech, automatism, and spontaneous speech

	Percentage of Consonants Correct (PCC)		
Variables	**Day 1**	**Day 10**	**Day 14**
ABFW (naming)	89%	97%	96%
Automatism	100%	100%	100%
Spontaneous speech	96%	98.6%	99.2%

Caption: mild (above 85%); mild-moderate (65% to 85%); moderate-severe (50% to 65%); severe (below 50%).
Source: the authors (2024).

The SHI aims to measure the impact of speech on the patient's quality of life after treatment for oral cavity and oropharyngeal cancer. Its self-reported scores decreased, and the speech-related quality of life improved; however, it was not maintained until she was weaned.[28,29,39]

Table 2. Scores of the Speech Handicap Index (SHI)

	Speech Handicap Index (SHI)		
Variables	**Day 1**	**Day 10**	**Day 14**
Scores	37	24	31
Speech classification	Average	Good	Good

Caption: Higher scores indicate worse speech-related quality of life.
Source: the authors (2024).

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The MDADI measures the impact of swallowing disorders on the subject's quality of life after treatment for head and neck cancer. The outcomes obtained throughout the intervention are shown in Table 3.

Table 3. Scores of the MD Anderson Dysphagia Inventory (MDADI)

	MD Anderson Dysphagia Inventory (MDADI)		
Variables	**Day 1**	**Day 10**	**Day 14**
Emotional	21	25	28
Functional	14	18	19
Physical	13	16	16
Global	48	59	63

Caption: Considering the global score: 0-20: deep limitation; 21-40: severe limitation; 41-60: moderate limitation; 61-80: average limitation; 81-100: minimum limitation.
Source: the authors (2024).

Below is a summary of responses to the instrument items applied throughout the intervention (days 1, 10, and 14).

Table 4. Summary of responses to each item in the Speech Handicap Index (SHI)

	Speech Handicap Index (SHI)		
Items	**Dia 1**	**Dia 10**	**Dia 14**
My speech makes it difficult for people to understand me.	2	2	2
I run out of air when I talk.	1	0	0
The intelligibility of my speech varies throughout the day.	2	2	2
My speech makes me feel incompetent.	1	1	0
People ask me why it's difficult to understand me.	3	2	2
I get upset when people ask me to repeat.	0	0	0
I avoid using the phone.	2	2	2
I get tense when talking to other people because of my speech.	1	0	1
My diction is not clear.	2	2	1
People have difficulty understanding me in noisy places.	3	2	3
I tend to avoid groups of people because of my speech.	0	0	1
People seem irritated by my speech.	2	2	2
People ask me to repeat when I talk face to face.	2	1	1
I talk less with friends, neighbors, and relatives because of my speech.	0	0	0
I feel I have to make an effort to speak.	2	1	2
I think other people don't understand my speech problem.	2	2	2
My speech difficulty restricts my personal and social life.	2	1	0
My speech intelligibility is unpredictable.	2	2	2
I feel left out of conversations because of my speech.	0	1	0
I make a great effort to speak.	2	0	2
My speech is worse at night.	1	1	2
My speech problem reduces my financial income.	0	0	0
I try to change my speech for it to sound different.	2	0	2
My speech problem makes me sad.	1	0	0
I am less sociable because of my speech problem.	0	0	0
My family has a hard time understanding me when I call for them at home.	0	0	0
My speech makes me feel incapacitated.	0	0	0
I have difficulty continuing a conversation because of my speech.	2	0	2
I feel embarrassed when people ask me to repeat.	0	0	0
I am ashamed of my speech problem.	0	0	0
How do you rate your speech at this moment?	AVER AGE	GOOD	GOOD

Caption: The first column presents each instrument item, followed by its respective self-reported scores on days 1, 10, and 14.
Source: the authors (2024).

Table 5. Summary of responses to each item in the MD Anderson Dysphagia Inventory (MDADI)

	MD Anderson Dysphagia Inventory (MDADI)		
Items	**Day 1**	**Day 10**	**Day 14**
My swallowing ability limits my day-to-day activities	1	2	2
I am embarrassed by my eating habits	2	2	5
People have difficulty cooking for me	1	1	2
Swallowing is more difficult at the end of the day	1	2	2
I do not feel self-conscious when I eat	2	2	2
I am upset by my swallowing problem	5	5	5
Swallowing takes great effort	1	2	2
I do not go out because of my swallowing problem	2	4	4
My swallowing difficulty has caused me to lose income	5	5	5
It takes me longer to eat because of my swallowing problem	1	1	1
People ask me, "Why can't you eat that?"	1	1	1
Other people are irritated by my swallowing problem	5	5	5
I cough when I try to drink liquids	4	5	5
My swallowing problems limit my social and personal life	2	4	5
I feel free to go out to eat with my friends, neighbors and relatives	2	4	2
I limit my food intake because of my swallowing difficulty	1	2	2
I cannot maintain my weight because of my swallowing problem	2	2	2
I have low self-esteem because of my swallowing problem	4	5	5
I feel that I am swallowing a huge amount of food	2	1	1
I feel excluded because of my eating habits	4	4	5

Caption: The first column presents each instrument item, followed by its respective self-reported scores on days 1, 10, and 14.
Source: the authors (2024).

5. Discussion

This is the first study in the literature describing the application of anodal tDCS in the primary motor cortex, associated with compensatory articulation therapy and myofunctional exercises to improve speech intelligibility in individuals after total glossectomy due to treatment for oral cavity cancer. The participant significantly improved the production of correct consonants, evident in spontaneous speech, naming skills, and the satisfactory production of previously inadequate phonemes (/k/ and /z/). There was also an absence and reduction of omissions of certain segments (/l/ and /r/, respectively) in simple and complex onset positions (see Figures 1 and 2).

Few studies approach speech intelligibility after partial or total tongue resection due to oncological treatment.[40] Adaptations to reestablish speech after the surgical procedure may occur at different articulatory points because of each subject's communicative particularities.[41]

The study participant had difficulty in producing the velar segments /k/ and /g/, substituted the voiced alveolar fricative /z/ for the voiced post-alveolar /ʒ/, and unsystematically and systematically omitted the /l/ and /r/ consonant groups, respectively. The substitution of the alveolar fricative segment for the post-alveolar segment occurred due to anteriorization and compensation with the orbicularis oris muscle during the vocalization of unrounded vowels (/a/, /e/, and /i/). Total glossectomized individuals are expected to have greater difficulty in these productions (given the important role of the tongue as an articulator) and in learning to compensate with the remaining structures.

Compensation was also identified through lip protrusion to produce isolated unrounded vowels (/a/, /e/, and /i/). Thus, she did exercises to increase proprioception and adapt articulatory points, resulting in correct production at the end of the intervention.

Oral cavity tumors affect speech intelligibility from the pre-treatment stage.[42] Guo et al.[43] verified with the SHI that 58.7% of individuals had speech disorders preoperatively, progressing to 91.2% after the surgical procedure. Those with larger resections also presented a worsening in speech-related quality of life.[43] As for the present case, the SHI improved after the SL intervention.

The study by Guo et al. found an SHI mean of 45.21 up to 30 postoperative days.[43] This case report found a score of 37 before tDCS application (despite the long postoperative period) and self-assessed "average" speech, evolving to 24 points and “good” speech intelligibility after 10 days of application and 31 points after 14 days, maintaining the self-reported "good" speech – demonstrating that the speech-related quality of life was better than at the beginning of the intervention. The slight decline in scores from the 10th to 14th day may be due to the decrease in exercises, which the participant did not perform periodically at home as instructed by the study SL pathologists.

Furia et al. described improved vowel production, vowel-consonant-vowel (VCV) sequences, and spontaneous speech in a group of total glossectomized individuals after SL rehabilitation.[13] This study found that PCC improved after the intervention, based on the collected ABFW speech and spontaneous speech, evolving from 89% in the evaluation to 97% at the end of the application. Hence, it demonstrates the benefits of intensive compensatory training associated with tDCS. Similarly, Hashemirad et al.[17] observed promising results after applying tDCS for motor learning and Lametti et al. for speech motor planning.[18]

At the end of the intervention, increased pain in the temporomandibular joint (TMJ) region was measured, scoring 0/5 in the intensity domain of the McGill Pain Questionnaire.[37] In addition to performing myofunctional exercises and compensatory training, anodal stimulation in the Primary Motor Cortex can also favor pain reduction.[44]

The therapeutic plan developed for this study correlates exercises to be performed according to specific changes, contributing to speech rehabilitation in glossectomized individuals, given the few and heterogeneous studies in the literature describing SL intervention in this population.[9]

The MDADI measures the impact of swallowing disorders on the quality of life of individuals after treatment for head and neck cancer. This study performed articulatory compensations and myofunctional exercises according to the patient’s need to maximize speech intelligibility. These exercises can also favor swallowing – the study observed a constant improvement in all instrument domains until the end of the intervention.

The videofluoroscopic swallowing study by Deng et al found increased oral and pharyngeal transit time and reduced laryngeal elevation and support in individuals with total glossectomy, increasing the risk of penetration and aspiration.[45] The author points out this population’s greater difficulty throughout the rehabilitation process, compared to individuals undergoing partial or subtotal resections. Deng et al. report a mean MDADI score of 47 points after 1 postoperative month, evolving to a mean of 61 points after 2 years, demonstrating a low trend of improvement in swallowing-related quality of life.[45]

Although the myofunctional exercises aimed to improve speech intelligibility, such structures are known to increase swallowing effectiveness simultaneously. Moreover, the area stimulated with tDCS (primary motor cortex) participates in saliva swallowing and may favor its execution when stimulated.[27] Initially, the participant had 48 points on the global MDADI, evolving to 59 and then 63 when the intervention was completed, corroborating the scores obtained in the study by Deng et al.[45]

A limitation of this case report is the intensive brief therapy applying tDCS for 10 days, the impossibility of statistical analysis, and the creation of a control group. It is known that intensive intervention is based on multiple principles, including exercise physiology and motor learning, favoring desirable changes, which is therefore a limitation of this study.[46]

Furthermore, a randomized blinded scientific study provides more robust outcomes and is, therefore, necessary to more assertively understand the impact of tDCS on the speech and swallowing rehabilitation of total glossectomized patients.[47]

6. Conclusion

In a total glossectomy patient previously submitted to traditional SL rehabilitation for speech and swallowing, tDCS associated with myofunctional exercises and articulatory compensation training favored speech intelligibility, improved speech-related quality of life, and reduced substitutions and omissions in speech, maintaining the improvements up to 30 days after the end of the intensive intervention. There was also a decrease in the impact of dysphagia on quality of life.

Authors contributions

The authors declared that they have made substancial contributions to the work in terms of the conception or design of the research; the acquisition, analysis or interpretation of data for the work; and the writing or critical review for relevant intellectual content. All authors approved the final version to be published and agreed to take public responsability for all aspects of the study.

Conflicts of interest

No financial, legal, or political conflicts involving third parties (government, private companies, and foundations, etc.) were declared for any aspect of the submitted work (including but not limited to grants and funding, advisory board participation, study design, manuscript preparation, statistical analysis, etc.).

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