folia medica

Folia Medica 67(1)
DOI: 10.3897/folmed.67.e144621

Original Article

The impact of diastema on the articulation of speech sounds

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Received: 16 December 2024 ♦ **Accepted:** 20 January 2025 ♦ **Published:** 25 February 2025

Citation: Georgieva-Bozhkova K, Konstantinova D, Nenova-Nogalcheva A, Nedelchev D. The impact of diastema on the articulation of speech sounds. Folia Med (Plovdiv) 2025;67(1): e144621. doi: 10.3897/folmed.67.e144621.

Abstract

Introduction: The faculty of speech in humans is a distinguishing trait that sets them apart from all other biological species. Speech production is typically achieved through the processes of phonation and articulation. The acoustic method of studying speech is an individual auditory approach based on hearing as a biological analyzer.

Aim: The present study aims to conduct a speech assessment of patients with single frontal maxillary defects, divided into two stages: an initial speech assessment before prosthetic treatment and a secondary speech assessment after temporary prosthetic restorations. The study will also investigate the factors influencing the improvement of sound articulation.

Materials and methods: A total of 40 patients (17 men and 23 women) with diastema and healthy vocal cords were included in the study for primary and secondary speech assessments. 60 speech therapy indicators were examined.

Results: In our study, improvement was observed in 30 out of 60 speech therapy indicators. The greatest improvement was noted in the pronunciation of alveolodental consonants ('S', 'TS', 'L'). A moderate negative linear correlation suggested that as age increased, the degree of improvement decreased (p=0.343).

Conclusions: The distortion of consonants in Bulgarian among patients with diastema remains within normal parameters. The richness of sounds in the Bulgarian language, in conjunction with the capabilities of contemporary dental prosthetics, underscores the necessity for subsequent in-depth studies of speech function following prosthetic rehabilitation in future research with a larger sample size.

Keywords

maxillary diastema, speech function, speech therapy assessment

Introduction

The capacity for speech in humans is a defining trait that sets them apart from all other biological species. Speech is typically executed through two processes: phonation, defined as the sound produced by the interaction between the air stream and the vocal cords, and articulation, characterized by the movement of speech organs, such as the tongue, cheeks, lips, teeth, hard and soft palate, uvula, and lower jaw, with or without contact between them.[1-4]

In the phonetic typology of Slavic languages, Bulgarian is classified as a language with accommodative pronunciation. This is characterized by a large number of contextually conditioned allophones of vowels and consonants. These are motivated either by the direct segmental context or by their position in the syllable/word, or by their distance from the stressed syllable. Furthermore, Bulgarian exhibits a pronounced qualitative reduction of vowels depending on the stressed syllable or vowel.[5,6]

In the Bulgarian language, consonants are classified into the following categories: glossopalatal ('ZH', 'Z', 'L', 'TS', 'R', 'S', 'CH', 'SH', 'SHT'), alveolodental ('S', 'Z', 'TS', 'L'), labiodental ('V', 'F'), glossodental ('D', 'T'), labial, and others. Vowels, on the other hand, are determined by the relationship between the lips and the tongue, ensuring unobstructed airflow from the oral cavity. The degree of distortion in sound production, when there are issues with the position and shape of the upper front teeth or their loss, is significantly greater when pronouncing consonants. This is due to the fact that teeth play a key role in the formation of the alveolo-dental ('S', 'Z', 'TS', 'L'), labio-dental ('V', 'F'), and glossodental ('D', 'T') consonants in the Bulgarian language.[4-12]

The methods employed for the study of speech function can be categorized as somatic and acoustic. Some of the somatic methods include phonography, palatography (static and dynamic), radiokinematography, and MRI for dynamic visualization.[13,14] Acoustic methods, which have been successfully applied in dental prosthetic treatment, include phonography, oscilloscopy[15], sonography, and auditory methods.[8] Sonography, an objective method, quantifies the frequency and intensity of voice signals over time, facilitating analysis of intonation and pronunciation.[16] Auditory methods are strictly individual and depend on hearing as a biological analyzer. Consequently, the evaluation of speech function by dentists is frequently subjective and lacks precision. The objective nature of the method is only possible when it is performed by a speech therapist, who utilizes specialized tests for speech assessment to evaluate sound articulation.[17,18]

All methods for assessing speech function that are listed above have been developed and proven for foreign languages. However, the development of a research method that is specifically tailored to the nuances of the Bulgarian language is imperative.

Aim

The objective of the present study is to conduct a speech assessment of patients with diastema, divided into two stages: initial speech assessment before prosthetic treatment and secondary speech assessment after temporary prosthetic restorations.

Materials and methods

Patients

A total of 40 patients (17 men and 23 women) with diastema and healthy vocal cords were included in the study for primary and secondary speech assessments. Each participant was provided with a comprehensive explanation of the potential risks and benefits associated with their involvement in the study and was subsequently asked to provide written consent. The study was approved by the Research Ethics Committee of the Medical University of Varna (Protocol No. 116/28.04.2022). The mean age of the participants was 49.56±3.16 years.

A thorough examination was conducted on all patients, revealing the absence of any pathology in the vocal cords. Additionally, it was observed that all patients exhibited a preexisting frontal maxillary defect **(Fig. 1)**.

Figure 1. A patient with a diastema, D.N., male, 35 years old.

The study was conducted in three stages: two clinical and one laboratory stage. During the initial visit of a patient, diagnostic impressions of the upper and lower jaws were taken using a two-step, double-layered technique, and occlusal registrations were obtained. Subsequent to this, master casts were fabricated and mounted on an articulator in the dental laboratory. The diagnostic wax-up technique was then employed to create a model for further analysis.

In the second stage of the clinical trial, a speech therapist conducted a preliminary speech assessment on patients exhibiting diastema, recognizing that accurately assessing speech distortions can be challenging in light of the dynamic nature of articulatory processes during continuous speech. The most reliable method for evaluating the phonetic quality of sounds involves analyzing disyllabic and monosyllabic words containing critical consonants at the initial position. To this end, a specialized methodology was developed to record distorted consonants, which contribute to incorrect pronunciation in Bulgarian. This methodology facilitated precise acoustic analysis (auditory method) for detecting changes in sound articulation. The evaluation included individual sounds, syllables, words, sentences, and spontaneous speech, with results systematically recorded in a specially designed speech therapy card.

The speech therapy card was adapted to align with the objectives of the study, drawing inspiration from the speech assessment card published in Regulation No. 6 (August 19, 2002) in the Official Gazette of the Republic of Bulgaria. For the present study, specific sections of the card were employed to assess sound articulation. The selection of sounds was based on their articulation characteristics and pronunciation principles, thereby ensuring consistency in the speech material's structure.

A self-polymerizing composite was used to fabricate a mock-up. It was made at the stage of diagnosis and treatment planning. It allowed visualization and prediction

with great accuracy of the aesthetic and functional outcome of the treatment. The examination of speech function at this stage allowed the patient to be supported in one's decision to undertake treatment. The permanent restorations were either lithium disilicate veneers or crowns, according to the indications. First, the vestibular surface of the teeth was processed, and then temporary structures were also placed. **(Fig. 2)**.

Figure 2. A patient with a mock-up, D.N., male, 35 years old.

During this phase, a follow-up speech assessment was conducted, adhering to the same stages as the preliminary evaluation under the supervision of a speech specialist. Data were once again recorded in the speech therapy card.

The participants were categorized into subgroups based on age and gender. The mean age of the group was 49.56±3.16 years, and participants were divided into two age categories: ≤50 years and >50 years. To determine whether daily speaking time impacted speech changes, patients were further classified into two groups: those speaking ≤4 hours per day and those speaking >4 hours daily.

All results were analyzed using IBM SPSS Statistics version 17, with a level of significance $\alpha=0.05$.

Results

All 40 patients were evaluated on 60 speech therapy indicators during both the preliminary and follow-up assessments. These indicators were analyzed before and after the temporary correction of frontal maxillary defects.

In 21 out of 60 indicators, no speech distortions were detected prior to treatment. These sounds did not require corrective measures, as their articulation remained unaffected even after closure of the maxillary defect. Sounds such as 'B', 'F', 'D', and 'T', along with syllables and short sentences containing the same sounds, exhibited no significant changes. Similarly, spontaneous speech demonstrated no variation in consonants 'B', 'T', and 'D' following prosthetic intervention.

In contrast, for 30 out of 60 indicators, the proportion of patients exhibiting distortions decreased after prosthetic treatment. Improvements ranged from 2.5% (e.g., sounds 'SH' and 'L') to 10% (e.g., sound 'TS').

Interestingly, 8 indicators demonstrated equal distortion levels both before and after treatment. Overall, improvements were noted in approximately 77% of the evaluated indicators following the temporary restoration of frontal maxillary defects **(Fig. 3)**.

The greatest improvements were observed in the alveolodental consonants ('T', 'D', 'S', 'TS', and 'L'). Notably, a 10% improvement was recorded for isolated sounds like 'TS', syllables containing 'S' and 'TS', and spontaneous speech involving 'L'.

Moderate improvements of 5% to 7.5% were seen in syllables and sentences containing 'TS', as well as sounds 'S' and 'Z.' Conversely, minimal improvements (2.5%) were recorded for 'SH', 'L', and 'CH'.

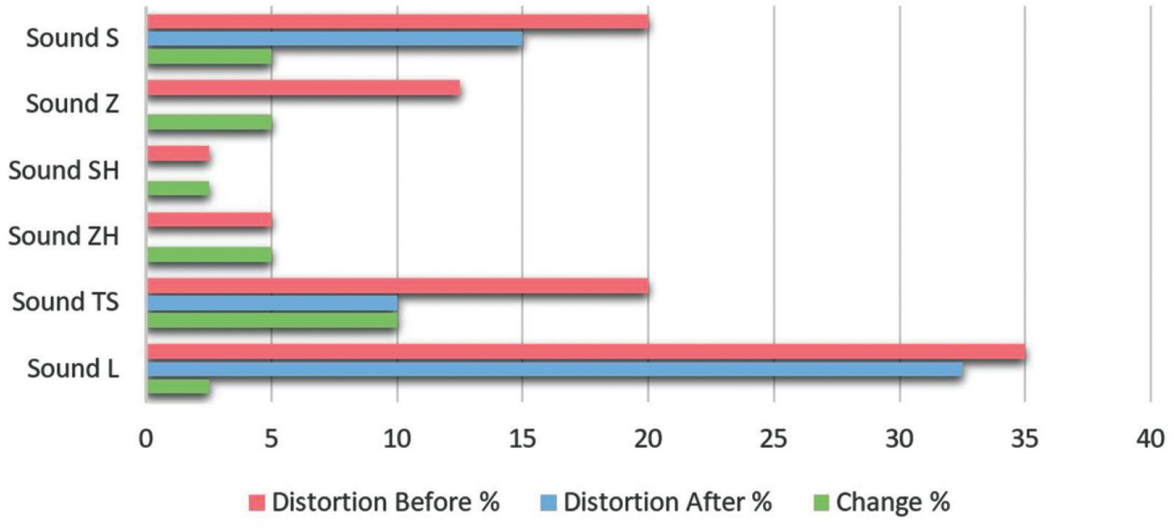

Figure 3. Changes in speech indicators before and after restoration.

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Evaluation of speech duration and age

As far as daily speaking hours are concerned no statistically significant correlation was found between hours spent speaking daily and changes in speech indicators (p=0.344).

Age exhibited an inverse correlation with improvement in speech indicators. Younger patients (≤50 years) demonstrated a higher frequency of improvement (35.3%) compared to older patients (>50 years, 21.7%). The correlation matrix revealed a moderate negative linear relationship, suggesting that as age increases, the degree of improvement decreases (p=0.343).

Discussion

The loss of teeth has a significant and negative impact on speech function in humans.[19]

Esthetic and phonetic considerations demand particular consideration when addressing defects in the frontal area of the upper jaw. Consequently, when fabricating non-removable prosthetic restorations, it is imperative to meticulously replicate the natural shape of the missing teeth, their inclination, and their dimensions to the greatest extent possible.[20-22]

It is well known that the upper frontal teeth, as well as the hard and soft palate, are involved in the articulation of sounds. The absence of upper incisors or their improper prosthetic restoration can lead to distortions in speech function.[19] They play a crucial role in the pronunciation of consonants such as 'S', 'TS', 'Z', 'T', 'D', 'L', and 'N'.

In their studies, Runte et al. found that the positioning of the upper central incisors more labially than their normal position leads to greater distortions in speech function compared to a more palatal position.[23,24]

In 2024, Palakolanu et al. compared the impact on speech function in different types of occlusion among 160 patients (69 men and 91 women). The results showed that patients with Class III malocclusion had the highest frequency of speech defects due to maxillary defects. According to the results, 54% of the participants in the study experienced difficulties in pronouncing lingo-alveolar sounds such as 'S' and 'T'.[25]

The influence of the design of fixed prosthetic restorations on speech was discussed in 2021 in a study by Hu et al. The authors found that changes in the morphology and arrangement of the teeth in the dental arches can affect the articulation of certain sounds.[26] Similar results were found in the studies by Weymuller[27] and Lu et al.[21] in 2020.

Our results also indicate an improvement in half of the speech therapy indicators after the restoration of a diastema. The data show a significant improvement in the pronunciation of consonants, with the most notable change, observed in the articulation of alveolo-dental consonants, such as 'S', 'TS' and 'L'.[28,29]

While studying the correlation between the age of patients and changes in their speech, Kaipa et al.[30] and Samani et al.[31] found that aging affected the speech fluency, which lead to deviations from standard pronunciation. This is also confirmed by our results: the greater the age of patients, the lesser the improvement in speech indicators (p=0.343). In the group of patients under the age of 50, a higher frequency of improvement in sound articulation was observed after the prosthetic restoration of single frontal maxillary defects. These improvements decreased with increasing age. Additionally, the results reveal an inverse correlation between improvements in speech therapy indicators and patient age (p=0.343), with younger individuals showing greater enhancements in articulation. However, no statistically significant association was found between daily speaking duration (p=0.972) and speech improvement.

During examination of other factors affecting the improvement of sound articulation, such as hours spent speaking per day (more or less than 4 hours) and the changes in speech therapy indicators, we found no significant correlation (p=0.972).

The richness of sounds in the Bulgarian language, along with the capabilities of modern dental prosthetics, suggests the need for further in-depth studies of speech function after prosthetic rehabilitation in future research with an increased sample size.

Conclusions

The distortion of consonants in Bulgarian among patients with diastema remains within normal ranges. Objective methods, which quantify distortions in speech function by presenting an assessment as a percentage of incorrectly reproduced sounds to the total number of produced sounds, are not employed. Consequently, auditory methods employed by a qualified speech therapist tend to be more precise and practically useful.

The primary challenge in conducting a precise quantitative evaluation of speech distortions in the Bulgarian language pertains to the development of a methodology for objectively measuring the phonetic quality of words as they are articulated.

The findings of this study indicate that during the wax-up and mock-up stages, potential distortions in the articulation of specific consonants in Bulgarian can be anticipated. This observation is particularly relevant for alveolodental sounds, such as 'S', 'TS', and 'L', both in spontaneous speech and in sentences containing these sounds. Early identification of these changes during the treatment process can significantly improve the prognosis for the final prosthetic restoration. The heightened expectations and demands of patients can be met through a more precise prediction of the outcome of diastema correction. The present study enabled the development and implementation of a specialized methodology for the study of Bulgarian speech. In addition, it revealed the influence of various factors, including age and the duration of speech during the day, on speech.

Author contributions

Conceptualization: Desislava Konstantinova, Kalina Georgieva, and Anna Nenova-Nogalcheva; methodology: Desislava Konstantinova; software: Kalina Georgieva; validation: Kalina Georgieva, Anna Nenova-Nogalcheva, and Desislava Konstantinova; formal analysis: Desislava Konstantinova; investigation: Dimo Nedelchev; resources: Anna Nenova-Nogalcheva; writing–original draft preparation: Kalina Georgieva; writing–review and editing: Desislava Konstantinova; visualization: Dimo Nedelchev; supervision: Kalina Georgieva; project administration: Desislava Konstantinova.

Funding

The authors have no funding to report.

Competing interests

The authors have declared that no competing interests exist.

Acknowledgments

We would like to acknowledge the support of Mrs. Ana Morfova – a speech therapist at the University of Varna.

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