

Association of incisal overlaps with /s/ sound and mandibular speech movement characteristics

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Introduction: Modern anterior restorations are intended to achieve esthetic and functional reconstruction and coordination. The positioning of the anterior teeth can affect pronunciation, but the effect of anatomic factors on pronunciation after anterior restoration has not been critically tested. The purpose of this study was to provide possible references for the design of the anterior overlaps in future anterior restorations. **Methods:** Thirty-nine subjects with normal occlusion (NO) participated. They completed questionnaires, were examined clinically, and were recorded pronouncing the /s/ sound. Links between overlaps with spectral features of the /s/ sound and mandibular movements during speech were investigated. **Results:** When NO subjects pronounced the /s/ sound, the average fricative length was 202.54 ± 44.57 ms; the average noise peak was 4052.89 ± 445.80 Hz, which was in the high-frequency region; the center of gravity was 2452.85 ± 623.50 Hz; and the mean intensity was 40.61 ± 4.99 dB. The mandibular speech movements showed a slightly long and narrow backward and downward oblique path. Overbite positively correlated with the /s/ sound's noise peak frequency and negatively correlated with the maximum closing speed. Overjet negatively correlated with the maximum distance in the sagittal plane. **Conclusions:** This is the first attempt to correlate the spectral features of the /s/ sound and speaking movements with incisal overlaps. The results suggest that significant associations exist and that these associations can offer some references for esthetic anterior restoration. (Am J Orthod Dentofacial Orthop 2019;155:851-9)

Esthetic dental restoration has become an area of intense interest. This is especially so for the reconstruction of shape, color, and occlusion of anterior teeth. However, these esthetic elements are closely related to stomatognathic functions, including mastication, articulation, and mandibular movement.¹ Because anterior teeth are an important structure of the

stomatognathic system, any abnormal changes in various aesthetic elements may cause compensatory alterations in the neuromuscular system, which might influence mandibular protrusion, lateral occlusal motion, and articulation and may even lead to functional disorders, such as occlusion phonation and temporomandibular joint disorder.² Therefore, for the esthetic restoration of the anterior teeth, both esthetic and functional aspects should be taken into consideration to achieve the harmonization of esthetics and function.

In many cases, certain anterior teeth malocclusions show a relationship with speech defects. Farronato et al³ suggested planning a multidisciplinary approach, including orthodontics and speech therapy, because the effect of malocclusion on dyslalia appears to be more frequent and increases proportionally, depending on the severity of the malocclusion. Ocampo-Parra et al⁴ conducted a cross-sectional study of the relationship between anterior open bite malocclusion associated with speech disorders. They demonstrated that anterior open bite not only produced aesthetic and occlusal problems for the patient, but also modified the union of the vocal organs and thus affected the ability to communicate well. In conjunction with the lips, tongue,

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palate, and oropharynx, the anterior teeth play an important role in phonation, especially in the articulation of consonants via airflow obstruction and modification.^{5,6} Souza et al⁷ found that incisor overlap had a direct influence on the size of the speaking space of /s/ in dentate subjects.

Runte et al⁸ evaluated the influence of the maxillary central incisors free from adaptation phenomena with the use of spectral analysis. They found inclination angle alteration of the central incisor together with significant changes in spectral characteristics. Thus, correlational studies of the anterior teeth and pronunciation are important for analyzing and solving problems regarding the structure and functional changes of the stomatognathic system.

Clinical observation has shown that some patients, especially those with particular occupations, were not satisfied with the effects on pronunciation after partial anterior teeth repair, because their articulation was not clear and pronunciation was poorly adjusted. It has been reported that removable partial dentures may cause speech defects, possibly due to the base or artificial changes in the location and shape of anterior teeth. To achieve a good esthetic result, treatment may also change the tilt angle, that is, we may artificially change the stomatognathic system, leading to the unclear pronunciation.⁹

In patients treated with oral implant-supported prostheses, speech disorders are observed more frequently than in subjects with natural dentition.¹⁰ However, little attention has been paid to the relationship between speech, fixed crowns, and bridge repair. Although we can obtain esthetically pleasing results and may meet occlusion standards, it remains difficult to meet the needs of patients' individualized pronunciation characteristics.

Sibilants, a subset of fricative sound, are high-frequency sounds produced by a stream of air directed through a minimal incisal separation. The /s/ sound, a common sibilant, has been used to evaluate vertical dimension and to serve as a parameter for placing anterior artificial teeth.⁷ However, there are presently a very limited number of studies regarding the relationship between incisal overlaps with /s/ sound pronunciation and speech movements. In addition, there is no effective reference to determine the inclination of the labial side of the anterior teeth. Therefore, the present study intends to use the strong sensitivity of the /s/ sound to begin exploring the relationship between fricative acoustic features and overlaps. In addition, we use mandibular speech movement tracings to further explore the correlation between anterior overlaps and mandibular movement during speaking. With the

combined analysis of those 2 aspects, we aimed to discover spectral acoustic parameters and speaking movement characteristics related to anterior overlaps. We hope that this study will provide guidance for the design of anterior repairs and anterior teeth esthetic restorations.

MATERIAL AND METHODS

Ethical approval for this study was gained from the Ethical Committee of the Health Science Center at the authors' institution. Written informed consent was obtained from each subject.

Thirty-nine volunteers were evaluated by questionnaire and clinical examination. All of the examinations were carried out by the same experienced clinician. The average age was 22 years, and there were 18 men and 21 women. The inclusion criteria were as follows. 1. Each subject had a full permanent dentition of at least 28 teeth, and only third molars could be missing. 2. Clinically confirmed with the use of diagnostic casts, the first molars and canines exhibited class I relationships: the mesiobuccal cusp of the upper first molar bite rightly against the buccal groove of the lower first molar not reaching beginning mesiocclusion (the mesiobuccal cusp of the upper first molar bites rightly against the distobuccal cusp of the lower first molar) or beginning distocclusion (the mesiobuccal cusp of the upper first molar bites rightly against the mesiobuccal cusp of the lower first molar); and the upper canine is positioned between the lower canine and buccal cusp of the first premolar. Other teeth are straight and neatly aligned, and there is no noticeable space, torsion, translocation, and congestion. All of the subjects have no history of orthodontic treatment. 3. There were no symptoms of temporomandibular disorder, periodontal disease, or bruxism, and no history of dental treatment for these problems. 4. There were no neurologic or cognitive deficits. 5. All subjects were native speakers of Chinese, without speech, language, hearing, or neurologic difficulties.

All recordings were made in a fully anechoic chamber (a room designed to completely absorb the reflection of sound waves or electromagnetic waves and which is commonly used in acoustics to conduct studies).

The participants were asked to pronounce 3 syllables, /su/, /san/, and /si/, 3 times each. The common phoneme /s/ as the initial letter was taken in these 3 words to evaluate the /s/ fricative acoustic parameters (Fig 1). For recording, a 1/2-inch type 1 precision microphone was used with 10 cm between mouth and microphone. The sound signals were recorded by the Cooledit Pro software (Syntrillium Software Corp, Scottsdale, Ariz) and saved as WAV files. The sampling frequency was 22,050 Hz; the sampling accuracy was 16 bits. The

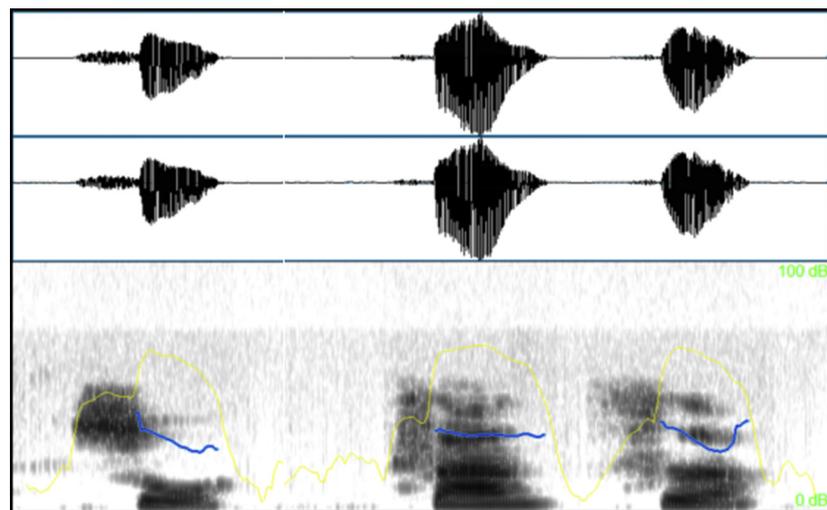


Fig 1. The speech spectrum diagrams for /su/ /san/, and /si/ (left to right).

sound files were analyzed with the use of spectrum analyzing software Pratt 2.0 (Phonetic Sciences, Amsterdam, The Netherlands).

Testing indexes were as follows. 1. Fricative length (ms) refers to the duration of the fricative consonant when speaking the relative syllables. Measuring starts from the high-frequency random pattern on the oscillogram to the occurrence of the vowel with low-frequency horizontal bar (Fig 2, A). 2. Mean intensity (dB) is the average intensity of the fricative during the friction period when speaking the syllables (Fig 2, B); this represents the strength of the sound and is proportional to the vibration amplitude of the vocal body. 3. Center of gravity (Hz) refers to the frequency value when the average energy is maximum in a certain frequency spectrum (Fig 2, C). 4. Noise peak (Hz) is the spectrum peak and refers to the place where the noise energy is most concentrated in the fricative speech. It is the main feature that distinguishes each fricative (Fig 2, D).

Mandibular speech movement was recorded on the Biopak II system BioEGN (version 5.01; Bioresearch, Milwaukee, Wis). The device consisted of an array of sensors that tracks the position of a magnet placed on the subject's lower central incisors to provide information regarding the position of the mandible. The upper crossbar of the sensor array on the subject's head is adjusted until it is parallel to the eyes and the sidebars are parallel to the Frankfurt plane in a snug fit. Also, the silver pointer should be about 5 mm from the magnet (Fig 3). Then BioEMG device was connected to a computerized system that records and displays spatial coordinates in the vertical, anteroposterior, and lateral axes, which were used to record the mandibular activity trajectory.

A phonetically representative assay was selected from a segment in the Mandarin national level test course—Zhu's prose work "Rush"—containing most of the commonly used pronunciation elements, such as syllables, phonetics, and tones, to encourage subjects to perform the speech movement according to their habitual loudness and other speech habits.¹¹

All subjects were informed of the study procedures and were familiar with the speech materials. To minimize the sensitivity and test errors, all subjects were required to sit in a standard test chair with head and torso in the orthostatic position until the end of recording. The following 2 tests were performed on each subject. 1. Incisal overlap measurement: Each subject moved the mandible from maximal intercuspation to the edge-to-edge position. The movement recorded in the vertical axis consisted of the vertical overlap (overbite), and the anteroposterior axis provided the horizontal overlap (overjet). Each recording was repeated three times.⁷ 2. Speech movement trajectory: After making the spontaneous /m/ sound and making swallowing movements, the subjects were in a state of natural relaxation and began in the cusp position to read the standard test essay at their habitual loudness and speed, 3 times at 1-minute intervals. The mandibular motion track images of the sagittal plane, coronal plane, and horizontal plane of each subject were recorded when reading the essays. The corresponding software was used to process and analyze the collected data. The data of velocities and 3-dimensional displacements in speech movements were obtained directly from the Bio-EMG software. The testing indexes were: Max.O (mm/s): maximum opening speed; Max.C (mm/s): maximum closing speed;

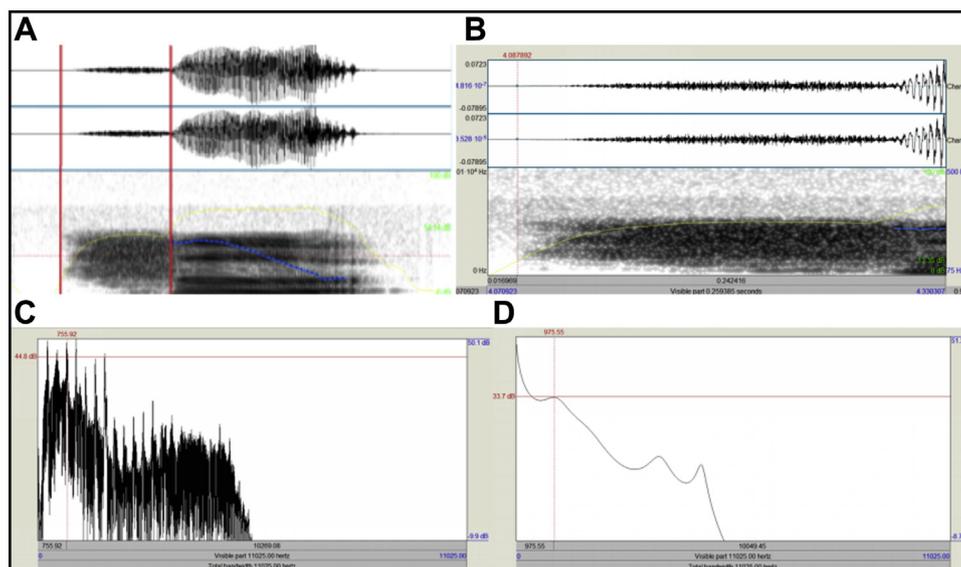


Fig 2. The spectrum analysis diagrams for /si/. **A**, The distance between the two red lines is the fricative length. **B**, The enlarged fricative segment is to evaluate the mean intensity. **C**, Center of gravity is directly measured by Pratt 2.0 software after fast Fourier transform. **D**, The intersection point of the 2 red lines is the noise peak.



Fig 3. Jaw movement trajectories were recorded with the use of the BioEMG instrument.

Vert (mm): maximum opening displacement in the coronal plane; A/P (mm): maximum displacement in the sagittal plane (sum of maximum protrusion displacement and backward displacement in the sagittal plane);

Slant (mm): maximum diagonal displacement; L (mm): maximum left displacement in the horizontal plane; and R (mm): maximum right displacement in the horizontal plane.

Statistical analysis

The statistical analysis was performed with the use of SPSS 19.0 software (SPSS for Windows; SPSS, Chicago, Ill). Descriptive statistics were used for the quantitative variables, and Student *t* test was used to compare groups. Correlation analysis was performed between variables (incisal overlaps with /s/ acoustic characteristics and the parameters of mandibular speech movement trajectory). The level of significance was $\alpha = 0.05$.

RESULTS

We made recordings from 39 participants with different overlaps and divided them into 2 groups: individual normal occlusion group (NO group; $n = 20$) and deep overbite/overjet group ($n = 19$; Table I). Subjects in the deep overbite/overjet group exhibited obviously greater overlaps, with upper anterior teeth covering more than one-third of the lower anterior teeth at intercuspal position (ICP; overbite) and overjet (maximum horizontal distance between the upper anterior teeth and the lower anterior teeth at ICP) > 3 mm.

The overlaps in the deep overbite/overjet group were larger than those in the individual normal occlusion

Table I. Overlaps of subjects (mean \pm SD)

Overlap	NO group	Deep overbite/overjet group
Overbite (mm)	2.90 \pm 1.23	5.00 \pm 2.15
Overjet (mm)	2.42 \pm 1.05	4.34 \pm 0.97

NO, normal occlusion.

group. Differences between the 2 groups were statistically significant according to 1-way analysis of variance: overbite: $P = 0.00065$; overjet: $P = 0.00001962$.

The /s/ sound acoustic features of individual normal occlusion participants are presented in Table II. According to the various vowels following the fricative /s/, acoustic characteristics displayed some changes. The initial fricative duration from large to small was in the sequence of /si/ > /su/ > /san/. The average intensity and peak value of noise showed a complementary trend. The initial noise peak of /su/ was the lowest of the three syllables, whereas the average strength of the sound was the highest among the 3 syllables. The noise peak of /san/ and /si/ were higher and very close to each other. Both the spectral center of gravity and the average intensity were in descending order of were /su/ > /si/ > /san/.

Table III presents the comparison of the acoustic parameters of the /s/ sound between the NO group and deep overlaps group. This demonstrated that the relative acoustic parameters were similar in the 2 groups and that there were no significant differences ($P > 0.05$).

The correlation with overbite and noise peak was positive, and the correlation coefficient was 0.391 ($P < 0.05$). There were no significant correlations between overlaps and fricative length, syllable duration, fricative ratio (fricative length/syllable duration), mean intensity, and center of gravity parameters (Table IV).

Overjet positively correlated with the mean intensity when pronouncing the /si/ syllable, with $r = 0.405$ (Tables V-VII; $P < 0.05$). Regarding the/su/syllable, overbite positively correlated with the noise peak of initial consonant, with $r = 0.363$ and $P < 0.05$, and overjet positively correlated with the mean intensity, with $r = 0.228$ and $P < 0.05$. There were no significant correlations between any index of the /san/ syllable and overlaps.

While subjects read the selected spoken text in a natural and steady-state voice, the mandibular movement characteristics were recorded (Fig 4). Overall, the mandibular speech trajectory exhibited a slightly long and narrow backward and downward oblique path. The position of anterior teeth moved from centric occlusion to a lower and backward position.

There were no statistically significant differences in terms of mandibular speech movement characteristics between NO group and deep overlaps group, with $P > 0.05$ (Table VIII). However, all of the parameters except the maximum right displacement in the horizontal plane in the NO group were larger than those of the deep overlaps group.

We found certain relationships between overlaps and speech movements in the present study. Overbite correlated negatively with the maximum back displacement in the sagittal plane, with $r = -0.469$ and $P < 0.01$. In contrast, overjet correlated positively with maximum right displacement in the horizontal plane, with $r = 0.360$ and $P < 0.05$ (Table IX). That is, with the increase in overbite, the maximum closing speed during mandibular speech movements showed a downward trend, although with overjet it increased gradually. The maximum horizontal displacement of the right side increased. This may contribute to pronunciation habits in some individuals. In contrast, the decrease in the maximum displacement in the sagittal plane may be due to pronunciation materials.

DISCUSSION

Mastication, esthetics, and pronunciation are 3 main functions of the anterior teeth. However, pronunciation is often overlooked during aesthetic restoration. Pronunciation is a complex functional movement that is influenced by many factors. It has been found that the articulation of sounds depends on the presence and position of teeth and on dental occlusion¹² to enable the points of contact and the restriction of air flow associated with the movements of the tongue, lips, and cheeks.¹³ Therefore, it is worthwhile to explore the relationships between the design of the anterior teeth position and pronunciation, which will improve the effects of esthetic restorations and match patients' desires for both esthetics and function.

Currently, the analysis of the closest speaking space and mandibular movements during speech has been confirmed to be useful for determining the vertical dimension of dental occlusion, anterior guideline and tooth position in the rehabilitative treatment of patients.^{14,15} In addition, because the generation of consonants is more closely related to teeth compared with vowels, and because the fricative sounds are sensitive and their spectral characteristics can be easily analyzed in acoustic studies, many dental and phonologic studies use fricatives as the preferred characteristic sounds for study. In the field of acoustic properties, fricative acoustic parameters include fricative length, noise peak, center of gravity, fricative

Table II. /S/ sound acoustic features of individual normal occlusion participants (mean \pm SD)

Parameter	/S/	/Si/	/Su/	/San/
Fricative length (ms)	202.54 \pm 44.57	231.88 \pm 59.08	225.11 \pm 46.67	158.68 \pm 40.83
Noise peak (Hz)	4052.89 \pm 445.80	4203.84 \pm 900.88	3886.76 \pm 428.85	4207.44 \pm 747.49
Center of gravity (Hz)	2452.85 \pm 623.50	2677.28 \pm 965.05	3282.17 \pm 727.55	1474.74 \pm 975.11
Average intensity (dB)	40.61 \pm 4.99	39.33 \pm 6.22	46.78 \pm 4.08	36.42 \pm 8.51

Table III. Comparison of acoustic parameters of /s/ sound

Group	Fricative length (ms)	Mean intensity (dB)	Center of gravity (Hz)	Noise peak (Hz)
NO group	202.54 \pm 44.57	40.61 \pm 4.99	2452.85 \pm 623.50	4052.89 \pm 445.80
Deep overbite/overjet group	193.86 \pm 24.22	40.00 \pm 3.81	2538.34 \pm 682.02	4242.84 \pm 541.24

Table IV. Correlations between overlaps and /s/ sound acoustic parameters

Parameter	Overbite	Overjet
Fricative length* (ms)	-0.018	-0.183
Syllable duration [†] (ms)	0.021	-0.176
Fricative length/syllable duration*	-0.006	-0.014
Mean intensity* (dB)	-0.034	0.135
Center of gravity* (Hz)	0.097	-0.009
Noise peak* (Hz)	0.391 [‡]	0.225

*Pearson correlation; [†]Spearman correlation; [‡] $P < 0.05$.

Table V. Correlations between overlaps and indexes of initial consonant in the /si/ syllable

Parameter	Overbite	Overjet
Fricative length* (ms)	0.054	-0.010
Noise peak [†] (Hz)	-0.050	0.109
Center of gravity [†] (Hz)	0.085	0.027
Mean intensity [†] (dB)	-0.159	0.405 [‡]

*Pearson correlation; [†]Spearman correlation; [‡] $P < 0.05$.

Table VI. Correlations between overlaps and indexes of initial consonant in the /su/ syllable

Parameter	Overbite	Overjet
Fricative length* (ms)	-0.155	-0.041
Noise peak [†] (Hz)	0.363 [‡]	0.248
Center of gravity [†] (Hz)	0.173	0.016
Mean intensity [†] (dB)	-0.014	0.228 [‡]

*Pearson correlation; [†]Spearman correlation; [‡] $P < 0.05$.

concentrated frequency area, and energy dispersion,^{16,17} which play important roles in characterizing and distinguishing the fricative acoustic features from various parts and methods of pronunciation. The fricative length, noise peak, and center of gravity are

Table VII. Correlations between overlaps and indexes of initial consonant in the /san/ syllable

Parameter	Overbite	Overjet
Fricative length* (ms)	-0.051	0.064
Noise peak [†] (Hz)	0.312	0.197
Center of gravity [†] (Hz)	0.315	-0.155
Mean intensity [†] (dB)	-0.029	0.030

*Pearson correlation; [†]Spearman correlation.

more widely used common parameters and were also evaluated in the present study. Because there currently exist some controversies in testing concentrated frequency area, which refers to fricative formants, this study did not use this parameter. In addition, the dispersion parameter requires specialized software and a large number of calculations, so it is too difficult to be included in limited conditions.

In the present study, we investigated the phonetic differences between deep overlaps subjects and NO subjects, as well as the possible associations between these 2 groups. The results demonstrated that the /s/ sound acoustic features in the NO group are consistent with the results reported in a previous study.¹⁸ The /s/ fricative showed some characteristic differences according to the subsequent vowels. The fricative length, ranked from high to low, showed that /si/ > /su/ > /san/. There was a complementary phenomenon between noise peak and mean intensity. In the 3 syllables, the noise peak of the initial consonant of /su/ was the lowest, whereas the mean intensity in descending order was /su/ > /si/ > /san/. This is probably because when we pronounce /su/, our lips are round, increasing the size of the sound cavity and reducing the acoustic vibration frequency so that peak noise will be lower. In addition, the tongue's position is high when producing the /su/ sound. The gap between the pronunciation structures was small for equal flow of air through the slit, making the friction

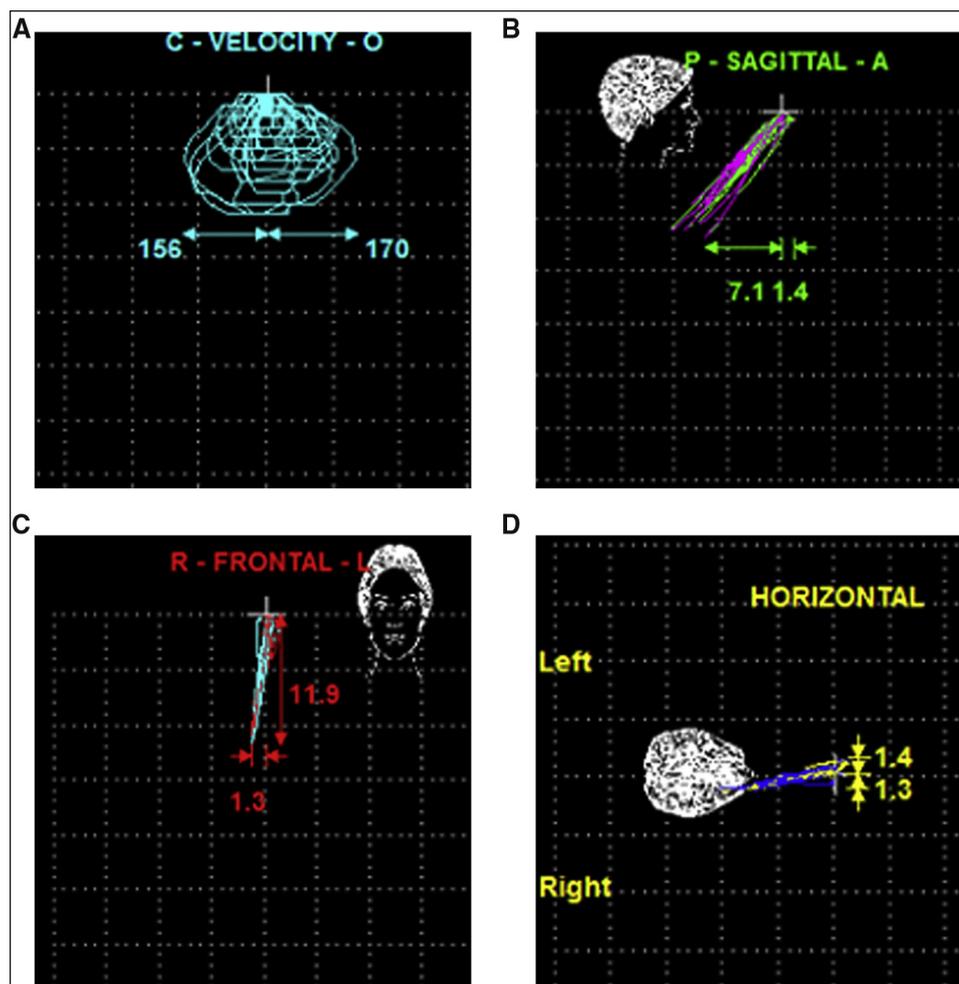


Fig 4. Mandibular speech movement trajectories in different planes.

energy greater. Yoshinaga et al¹⁹ found that the position of the tongue altered the main peak frequency and spectral mean of the generated sound. Tongue position and the fricative noise peak were closely associated when producing fricatives via air friction. The more forward the position of the tongue was, the higher the corresponding noise peak frequency, that is, the energy is concentrated in the fricative's high-frequency region. To a certain extent, the larger the overbite was, the more forward the tongue position.²⁰ Therefore, as a clinical implication, orthodontic or occlusal treatment should be one of the options considered for the diagnosis and treatment of functionally abnormal patients. It is noteworthy that the spectral center of gravity of the syllable /san/ was substantial and the standard deviation somewhat significant, which may be because the opening range of vowel /a/ was larger than the others, and people have varying habits regarding opening the mouth for producing /a/.²¹

Regarding the characteristics of mandibular speech movements for NO subjects, the present result is similar to that of Wang et al.²² In other words, 2 studies on normal mandibular speech movement characteristics, reading the same Mandarin materials, gave similar results. Previous studies^{1,23} reported that mandibular motion range during pronunciation is affected to some extent by anterior teeth malocclusion, such as open bite, deep overlaps, and crossbite. Deep overlap is inversely related to the maximum anterior extension movement. The present study also suggested that with the enlargement of the incisor overlap, the maximum mouth closing speed of the mandibular speech movement tended to slow down. This may be because the sliding trajectory of the teeth with deep overlaps increases when closing the mouth to the intercuspal position. Subjects deliberately slowed down the speed of closure to avoid the impact between the upper and lower anterior teeth. Furthermore, the overjet is

Table VIII. Mandibular speech movement characteristics

Parameter	NO group	Deep overbite/ overjet group	t/Z	P value
Max.O (mm/s)	113.33 ± 37.27	96.52 ± 33.1	1.215	0.232
Max.C (mm/s)	94.87 ± 30.04	74.04 ± 29.6	1.794	0.081
Vert (mm)	12.54 (8.47-12.87)	11.07 (7.77-11.63)	-0.867	0.386
A/P (mm)	4.82 ± 2.81	3.17 ± 2.74	1.550	0.130
Slant (mm)	12.14 ± 2.74	10.93 ± 3.21	1.111	0.274
L (mm)	1.54 (1.10-2.00)	0.97 (0.60-1.83)	-1.184	0.236
R (mm)	1.67 ± 0.8	1.92 ± 1.06	-0.877	0.386

Max.O, maximum opening speed; Max.C, maximum closing speed; Vert, maximum opening displacement in coronal plane; A/P, maximum displacement in sagittal plane (sum of maximum protrusion displacement and backward displacement in sagittal plane); Slant, maximum diagonal displacement; L, maximum left displacement in horizontal plane; R, maximum right displacement in horizontal plane.

Table IX. Correlations between overlaps and mandibular speech movements

Parameter	Overbite	Overjet
Max.O* (mm/s)	-0.208	-0.150
Max.C* (mm/s)	-0.355 [‡]	-0.295
Vert* (mm)	-0.068	0.008
Maximum protrusion displacement in sagittal plane (mm)	-0.010	0.203
Maximum back displacement in sagittal plane (mm)	-0.100	-0.469 [§]
A/P (mm)	-0.125	-0.454 [§]
Slant [†] (mm)	-0.171	-0.225
L [†] (mm)	-0.030	-0.232
R* (mm)	0.138	0.360 [‡]

Abbreviations as in Table VIII.

*Pearson correlation; [‡]Spearman correlation; [‡]P < 0.05; [§]P < 0.01.

negatively related to maximum displacement in the sagittal plane (A/P) in this study. To a certain extent, it indicated that the lowest point of jaw opening is forward and the anteroposterior movement of jaw is narrowing according to the increase of overjet, although the exact reason for this result may need further study on a variety of pronunciation materials that involve more words requiring mandibular protrusion and backward displacement. The correlation between the maximum horizontal displacement on the right side and overlaps may be related to the pronunciation habits of specific people.

Comparing the /s/ sound's spectral characteristics and the mandibular speaking movement indicators of the 2 groups, the study results showed that there was no significant difference between the 2 groups, a different finding from that of Pakkala and Qvarnström.²⁴ There are several possible reasons for this result. First, the number of subjects involved in our study was small, and the degree of deep overlaps may not be severe enough to cause noticeable acoustic and speech movement changes. Second, the mild

malocclusion of teeth can trigger the neuromuscular compensatory pronunciation system rather than drive significant changes in mandibular speech movement. Moreover, it may be related to the pronunciation of particular words in the selected speech materials or potentially due to another unaccounted parameter in each individual. Therefore, to be more representative, it is necessary to further expand the sample size in future studies. In addition, the distribution range of subjects should not be confined only to a school but should also compare the differences of different speech materials and languages. Also, it is indispensable to undertake similar measurements on patients before and after treatment in further research by creating a series of temporary crowns for anterior teeth with different overlaps to minimize the individual differences and provide far more reliable data. Compared with the normal values of acoustical features and mandibular speech movement in large enough samples, it will effectively guide the design of the overlap of the denture in anterior teeth esthetic restoration.

CONCLUSION

Within the limitations of this study, for the detection of specific phonetic materials the incisor overlaps correlated with the acoustical features of the /s/ fricative and with the mandibular speech movement of the anterior teeth. Specifically, incisor overlaps affect the indexes of the maximal closing velocity of the maxillary phonetic /s/ acoustical noise peak and sagittal maximal retrogressive displacement. Therefore, the peak noise at /s/ fricative and the maximal closing velocity in mandibular phonation were the preferred parameters, and /su/ and /si/ tones were the most preferred syllables for testing pronunciation in denture wearers. This finding is clinically meaningful to guide the design of anterior restorations.

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