



The Effect of Malocclusion on Kurdish Young Children's Production of Dental, Labio-Dental and Alveolar Sounds: A Case study

Dlakhshan Yousif Othman (PhD)

College of Basic Education / Salahaddin University-Erbil

dlakhshan.othman@su.edu.krd

Abstract

The purpose of the present study is to investigate the effect of malocclusion on the production of dental, labio-dental, and alveolar fricative and stop consonants. To achieve this purpose, Fifteen Kurdish young children ranging in age from 8-12 years old were selected to participate in the current study. They were distributed over three groups according to their bite-block occlusions. The participants were asked to pronounce isolate fricative and stop sounds and words which include target sounds, and their voices were recorded. Later, the patricians' audio-recordings were analyzed via a software praat analysis (wave form and sound spectrograph). The main conclusion of the study was that the children with malocclusions had difficulties in producing the inter-dental, labiodental, and alveolar sounds properly. In addition, distocclusion, open-bite and extra orally deep-bite malocclusions were more significant than other types of malocclusions in affecting target sounds production

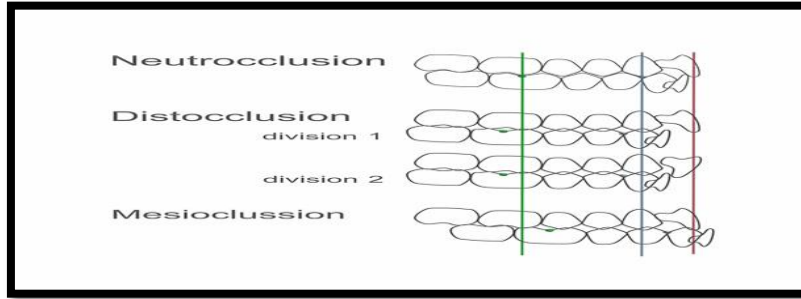
Keywords: Malocclusion, Acoustic prosperity, Fricative and affricate, Kurdish young children.

1- Introduction

One of the central concerns in applied phonetics and phonological studies is the discovery of sound production in young children and to identify factors that affect the development of their speech. Recently, the relationship between the malocclusion and sound production has been viewed in a number of clinical phonetic studies (Warren, Nelson, & Allen, 1980; Edwards, 1991; Nielsen, 1992; Green, et al., 2002; Solomon, et al, 2016; Kaur, 2017; Green, et al., 2002) and considered as one of the factors that affect young children sound and speech production. The studies tried to evaluate the relationship between children's bite-blocks and sound production. Investigating children's malocclusions and their movements during producing speech sounds has become the focus of attention of the researchers.

As it has been scrutinized clinically, abnormal Jaw movements and malocclusion cause, to some extent, speech disorder. The effects of malocclusion on the normal production of sounds, and temporal aspects of speech have been examined carefully to intensify the understanding of speech motor control and speech motor planning (Baum, McFarland, & Diab, 1996; Flege, Fletcher, & Homiedan, 198; Folkins, Linville, Garrett, & Brown, 1988; Gay, Lindblom, & Lubker, 1981; McFarland & Baum, 1996). Warren, Nelson, & Allen (1980) identified that the normal height of bite-blocks in stabilized jaws are ranging between from 2 mm to 2.5 mm, and intermediate sizes (5–15mm).

Nielsen (1992) identified that the causes of the malocclusions mostly are vertical skeletal growth imperfection, habit disorders, or both factors. Solomon, et al (2016) recognized three main types of occlusion, namely, normal occlusion (neotrocclusion), open-bite and deep-bit which are recognized as two types of distocclusion, finally under-bite or cross-bite which are scientifically known as misocclusion. See Figure (1).



Figure(1) Angles occlusion classification (cited in <https://www.houstonmethodist.org>)

According to Kaur (2017) children with abnormal occlusions and articulatory speech disorder commonly have problems with sound productions. Teeth are considered as main articulators in human speech organs in which different sounds are formed with their involvement, vowels and voiceless frictions. The lack of even and upright teeth and normal occlusion can cause that does not occur normal sound.

The current study high lights the impact of malocclusion on consonant sounds' production. More precisely, it tries to investigate dental/ t, d, θ, ð/, labio- dental /f,v/ and some alveolar consonant sounds/ʃ, ʒ, s, z, / production in Kurdish young children with imperfect malocclusion. In order to achieve the aim, this study addressed the following questions:

1. To what extent malocclusions affect children's production of dental, labio-dental and alveolar consonant sounds?
2. Which type of malocclusion has the most potential effect on the negative production of the target sounds?

Based on the above questions, the researcher has put forward the following hypotheses:

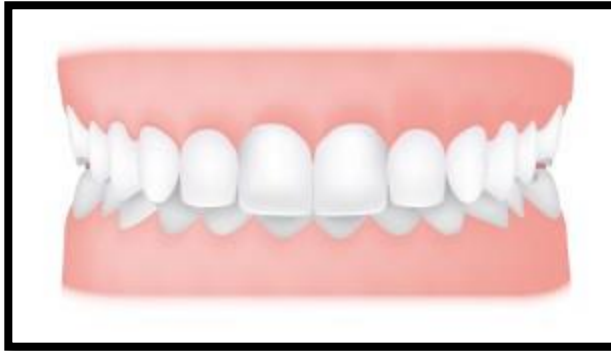
1. Malocclusions have a negative effect on children's production of dental, labio-dental and alveolar consonant sounds?
2. All the types of malocclusions equally cause auditory problems to the production of the target sounds.

2. Theoretical framework

2.1 Angle's categorizations of malocclusion

In 1899, the scholar Edward H. Angle distinguished three different types of malocclusion based on the molar relationship, namely the maxillary permanent of the first molar (Proffit, et al, 2019). In other words, the imperfection growth of anterior upper and lower front teeth. Based on Angle's categorization the three classes are as follows:

1. Class I: Neotroclusion or normal dental occlusion is a normal alignment of the upper maxilla and lower mandible. In other words, there is a kind of accommodation between the upper and lower permanent teeth bite-blocks, as in the following figure:



Figure(2) normal occlusion

2. Class II: Distocclusion, The second type of malocclusion has two forms, namely, deep- bite and open-bite occlusions. The former is a misalignment of the permanent teeth in which the central and lateral permanent incisor teeth overlaps over the bottom incisors in the mandible. While in the open- bite malocclusion, the front upper and lower incisor teeth are sloping outward, so there is no contact between the upper permanent teeth in the maxilla and the incisors in mandible when the mouth is closed. In addition, the upper and lower dental spacing is more than 2.5 mm. See the following figures.



Figure (3) deep and open occlusions

3. Class III: Mesioocclusion or bilateral cross-bite is an abnormal type of malocclusion defined by Angle in 1899. The lower central incisor teeth, and premolar, in the type class III malocclusions, occlude anterior to the upper front incisors. This means that the lower jaw (mandible) articulates further forward in relation to the upper permanent incisors (maxilla), causing reversed in the overjet (Mageet , 2016). See figure (4).

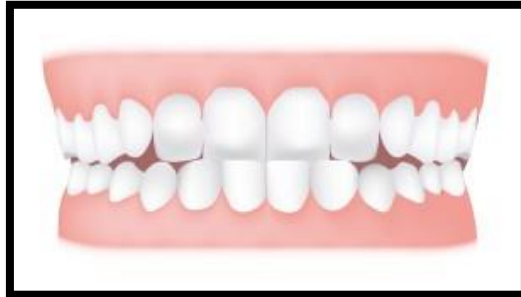


Figure (4) cross-bite occlusion

2.2 Articulatory properties of dental, labio-dental and alveolar sounds

Fricatives, in phonetics, are described as a group of consonant sounds, which are produced by making a narrow constriction the passage of the airstream via different organs of a vocal tract, but not forming complete closure, so that air moving through the mouth cavity generates audible friction. Fricative sounds include sounds like / f, v, s, z, θ, ð/. All the fricative sounds are produced almost in the same manner, in different languages, but with different places of articulation. For instance, the sounds /f, v/ are produced by making a narrow constriction between the lower lip and upper front teeth.

For / s, z /the construction is forms by raising the tongue tip to be close to the alveolar ridge. Dental, sometimes interdental, sounds / θ, ð/ are produced with a constriction between the tongue tip and the edge of the upper and lower front teeth. (Roach, 1980)

Whereas, stop consonant sounds like /t, d /which begin with a complete contact. In other words the oral passage is blocked by pressing the tongue tip against the alveolar ridge; the breath is compressed behind the articulators and then released in a burst. (o'conor, 1973)

Wais (1984) identifies that the fricative and affricate sounds are also found in Kurdish sound symbols, except for / θ, ð /. They almost have the same manner of articulation and they are produced in a similar places Kurdish speakers have no problem in recognizing and producing them. The two plosive sounds /t, d/are dental – alveolar sounds in Kurdish sound system.

2.3 Acoustic properties of fricative and stop sounds

This sub- section highlights the acoustic properties of the labio- dental, dental, and alveolar fricative sounds, as well as the alveolar stop sounds, as the acoustic features present exemplary indication to isolate, voicing , duration, frequency and other important features of phonemes.

The spectral features, amplitude (dB) , onset frequency (F) and noise duration of the target sounds / f, v, s, z, θ, ð, t, d/ have measures based on a standard measurement scale was predetermined by Acoustic Phonetic Laboratory Manual at the University of Victoria . More specifically Lab 5 which was designed by Paul Boersma and David Weenink to measure the acoustic correlates of obstruent place of articulation of the fricative and stop consonant sound. (Bird, et al, 2019)

According to Jongman, Wayland, and Wong (2000), the average durations are: 174 m for /s/, 176m for/z/, 149m for /f/ , 152m /v/ , 134m for /θ/ , 137m for [ð]. Besides, the averages of dB for the mentioned fricative sounds are: 10, 17, 49, 50, 64, and 63 dB, respectively.

Moreover, the mid-frequency spectral (F) of the above sound, which are measured at a 10 kHz rate with a 40 kHz low-pass rate and a 10-bit quantization, are as follow: 4 to 5 kHz to the sounds /s, z/; 2.5 – 3 kHz for the labio- dental sound [f, v]; 6.5-7kHz for the interdental sound [θ , δ]. (Behrens and Blumstein, 1988)

The spectral properties of the stop/ plosive noise are as follow: 121m for the sound /t/ and -130m for the sound /d/. And, the overall amplitude of the mentioned stop sounds records 75, and 72. Behrens and Blumstein (1988) state that there are changes in the overall dB of the sound noise, but to some extent there are consistency in the spectral features across time. In addition, the mid-frequency spectral for the alveolar plosive sounds /t, d /, based on the Acoustic Phonetic Laboratory Manual, is 9- 11 kH.

2.4 Previous Studies

A number of studies have been carried out to investigate the effect of malocclusion on the sound production. Edward (1991) conducted a study entitled “Compensatory speech motor abilities in normal and phonologically disordered children. In this study, Edward tried to examine acoustically the effect of a bite-block on the production of normal vowels. The subjects were 10 preschool children. She aimed to investigate vowel production in normal and phonologically disordered children .The results showed that the phonologically disordered children are much less consistent in producing the vowel sounds. Also, they could not show systematic effects of the experimental jaw conditions in comparison to the normal children.

Lane et al. (2015) carried out an experimental study to explore the effects of hearing status and bite blocks on vowel production. The experimental group comprised of six male and two female postlingually deaf, adults, while the control group was comprised of four male and six female participants. Both groups received bite blocks and short-term interruptions of auditory feedback. Edward conducted her study to obtain a greater understanding of feedback present a year after processor activation, both without and with bite blocks. The results of the study revealed that the insertion of the bite blocks

interruptions reduce the size of the vowel spaces. In other words, the vowel space had grown when it was measured with auditory.

In a study by Kaur & Nedal in 2017, they tried to evaluate the relationship between malocclusions and sound production. They found out that there was a strong relationship exists between speech disorder and tooth position. They revealed that out of 54 patients, auditory distortions occurred in 29 of them, and they had visual distortions. A similar study carried out by Leavy, et al, (2018) entitled “Malocclusion and its relationship to speech sound production: Redefining the effect of malocclusal traits on sound production”. The researchers’ main purpose was to identify variables of dental malocclusion with the greatest effect on sound production. To achieve their aim, they assessed how speech sound abnormality had in an orthodontic clinical examination. The results of this study showed that certain features of malocclusion could compromise proper sound production, and the amount of more speech sound errors depends on the severe or handicapping the malocclusion.

The focus of the current paper, as mentioned previously, is only on the effect of malocclusion on the Kurdish young children’s production of certain consonant sounds, specifically the sounds that are produced with the immediate part of the mouth, namely, / t, d, θ, ð, s, z, f, v/. Furthermore, the examination of the occlusion and phonetic is conducted and compared to find out which type of malocclusion has the greatest effect on the production of the target sounds.

3.0 Methodologies

3.1 Participants

To achieve the aim of the study 15 Kurdish young children, aged between 8 - 12, recruited according to their bite block for the current study. They distributed into three groups, the first group includes four children with normal occlusion (Neutroocclusion), the second group includes seven children with Distocclusion, 3 children with open- bite and 4 with deep- bite and the final group includes four children with under- bite or cross-bite

(Mesioocclusions).

3.2 Procedure and material

Samples' voices were audio recorded in a sound isolated room using a Philips Speech Air Smart Voice recorder, (PSE 1200), microphone speech-editing software placed 8–10 in. To acquire accurate results, the researcher used a software praat analysis version 6.0.43 to analyze the samples' recording and to derive spectral measures for the acoustic analyses. The samples were asked to pronounce a group of alveolar and dental sounds, solitary and in words. Also, they were instructed to read a list of words include the target occurred in different positions in the words, i.e., initial, medial, and final position. The participants were familiarized with words as they had studied previously: **Farm, craft, roof, tart, late, star, dad, Monday, loud, beside, spider box, zebra, lizard, buzz, think, bath, healthy, mother, this, with.**

3.3 Ethical Considerations

To ensure the confidentiality of study, the researcher explained all the research detail to all participants' parents and provided them with a written informed consent before enrolling their children in the current study. They were informed of their right to withdraw if they want to. Besides, they have been assured that the anonymity of the samples will be maintained strictly and their name and identity will be all kept confidential.

4.0 Data Analysis and Discussions

To answer the first study questions which reads: To what extent malocclusions affect children's production of dental, labio-dental and alveolar consonant sounds?

Participants' sound records have been analyzed via software praat analysis version 6.0.43, as mentioned previously. The spectrograms of the records of the three children with open-bite occlusion show that they are unable to produce the dental and alveolar sounds properly. Based on Acoustic Phonetic Laboratory Manual, the friction of their production of alveolar sound/ s, z, θ, ð/ are slightly weak due the jet between first permanent molar and lower teeth arch. In other words, the wide jet between the upper and lower front teeth prevents the narrow passage to be formed for a noticeable friction. The following pictures show the malocclusion of the samples with open-bite occlusion.



Sampe-A-

sample -B-

sample-C-

Figure(5) participants with open- bite malocclusions

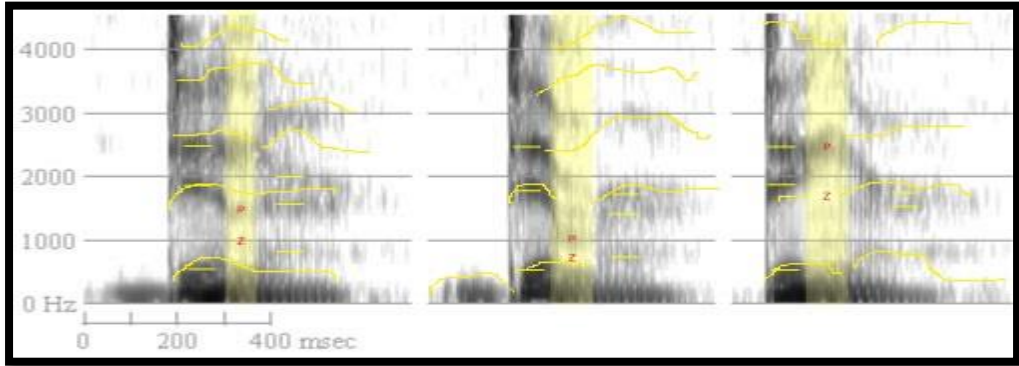
In addition the septogram of their records show that close frequency for the dental and alveolar fricatives/ s, z /; alveolar stop/ t,d/; inter-dental/ θ, ð /;and labio-dental /f,v/ are as follow:

Table (1) spectral analysis of kurdish young childern with open-bite malocclusion

Sound features	Sounds	Participant A	Participant B	Participant C
Sound duration	/ θ, ð/	=(130- 132)	=(131- 133)	=(127- 129)
	/s, z/	= (158-159)	= (156-161)	= (155-156)
	/t,d/	=(119- 123)	=(117- 122)	=(117- 121)
	/f,v /	= (147- 149)	=(147- 148)	=(146-148)
Frequency (F)KHZ	/ θ, ð/	= (2-2.9)	=(0.75-1)	=(0.8-1)
	/s, z/	=(3-3)	=(3-3.5)	=(3.2-3.9)
	/t, d/	=(7-8)	=(7-9)	=(8-10)
	f,v	=(0.25-0.5)	=(2,9- 3)	=(2.9-3.2)
Amplitude dB	/ θ, ð/ =	=(58- 60)	= (60-61)	=(55-57)
	/s, z/=	= (7-8)	= (9-9)	= (5-7)
	/t, d /	=(73-75)	=(72-74)	= (71=73)
	f,v	= (6-6.8)	=(6.1- 6.6)	=(6-6.5)

The analyses of spectrogram data show that the open-bite malocclusion's effect on the production of alveolar / t, d/ and labio-dental/ f, v/ are not very different from the normal range of sound spectrogram of a person with an ideal occlusion since they are produced with different articulators, namely tip of the tongue ,alveolar ridge, and lower lip.

The following figures are samples of the sound wave of the participant



Figure(6) samples of the sound wave of the participant

The features of sound analysis of children with deep-bite malocclusion were as follow:



Sample -D-

Sample -E-

Sample-F-

Sample -G-

Figure(7) participants with deep- bite malocclusions

The spectrogram analyses of the children with deep-bite malocclusion show that the participants with extra-orally malocclusion, samples F and G, have the greatest problem with /f, v, / due to the lack of lower lip support and the absence of immediate friction, moreover, the participants with this type of malocclusion have difficulties in occluding the upper and lower front teeth appropriately to produce the inter-dental sounds /θ, ð/ and alveolar sounds /s, z /with suitable friction. More precisely, the participants who have an intra-orally malocclusions, with 7 mm, were unable to reach the exact sound placement for the mentioned sounds, in comparison to samples: A, B, C, D and E. The spectral analyses of the participants' audio records show that

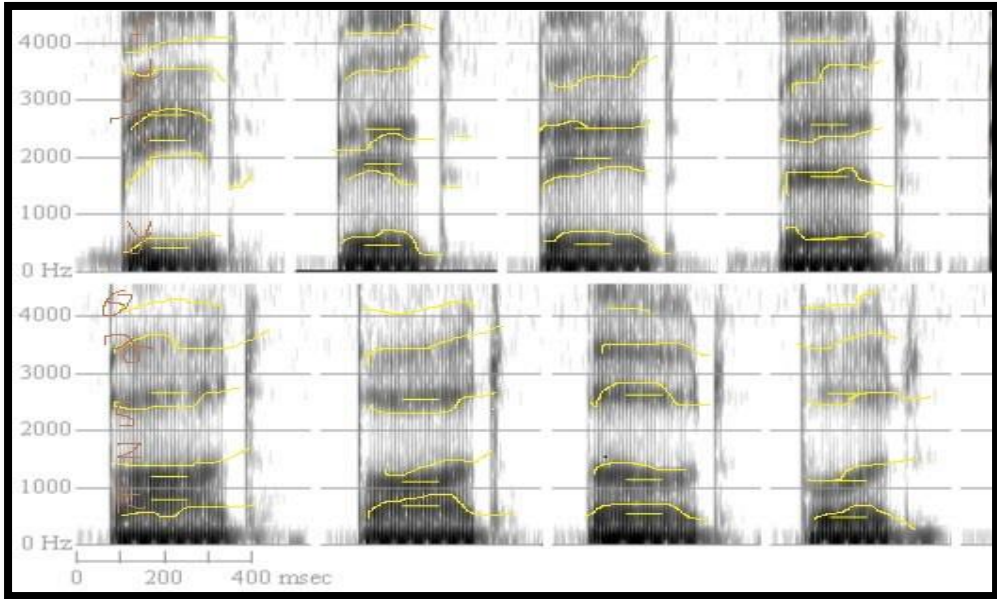
samples F and G produce sound /f, v, θ, ð and s, z/ with less duration and weak frequency. See table 2. The participants with extra- interior upper teeth are unable to form a contact to form a normal narrow passage with the lower front teeth to produce, inter-dental, and alveolar fricative sounds properly. In addition, the space between their first permanent molars and lower arches prevent them to form the suitable narrowing between the upper front teeth and lower front teeth for producing the labio-dental sounds. So, the sounds /f,v/ are produced with less friction and less noise.

On the other hand, samples D and E, with intra- orally malocclusion (less than 6mm), have less problem in the production of the inter-dental, and labio-dental, and alveolar sounds, except for the alveolar sounds/s, z/ which appeared to be less fricative.

Table (2) spectral analysis of kurdish young children with deep-bite malocclusion

Sound features	Sounds	Participant D	Participant E	Participant F	Participant G
Sound duration	/ θ, ð/	=(134- 136)	=(135- 136)	=(122- 125)	= (120-124)
	/s, z/	= (170-172)	= (159-1631)	= (144-148)	=(141-146)
	/t,d/	=(119- 123)	=(123- 129)	=(120- 127)	=(119-125)
	/f,v /	= (149- 15)	=(149- 150)	=(139-142)	=(137-140)
Frequency (F)KHZ	/ θ, ð/	= (2-2.9)	=(1.5-2.5)	=(0.8-1.5)	=(0.9-1.5)
	/s, z/	=(3.5-4,5)	=(4-5)	=(2.5-3)	= (2.2-2.9)
	/t, d/	=(8-10)	=(8-10)	=(5-8)	=(5.2-8.5)
	/f,v/	=(2.7-3.5)	=(3- 3.5)	=(2-2.9)	= (2-2.5)
Amplitude dB	/ θ, ð/ =	=(60- 63)	= (64-68)	=(50-53)	=(52-55)
	/s, z/=	= (8-9,5)	= (10-12)	= (3-6)	=(3-5.5)
	/t, d /	=(74-76)	=(76-75)	= (69=70)	=(65-69)
	/f,v/	= (7-9)	=(6.5-7)	=(4- 5.5)	=(4-5)

The below spectrogram show the production of the target sounds by children with deep bite occlusion.



Figure(8) samples of the sound wave of the participant

The samples of the third group, as it is mentioned previously include four children with cross-bite occlusion. This type of malocclusion is known as a Mesiocclusions according to Angle classification. The samples' productions of the target sounds have been audio recoded to explore the effect of this of malocclusion on their production of inter-dental, labio-dental and alveolar sounds. Figure (9) include samples with Mesiocclusions bite- blocks:



Sample H

sample I

sample J

sample K

Figure(9) participants with cross- bite Malocclusions

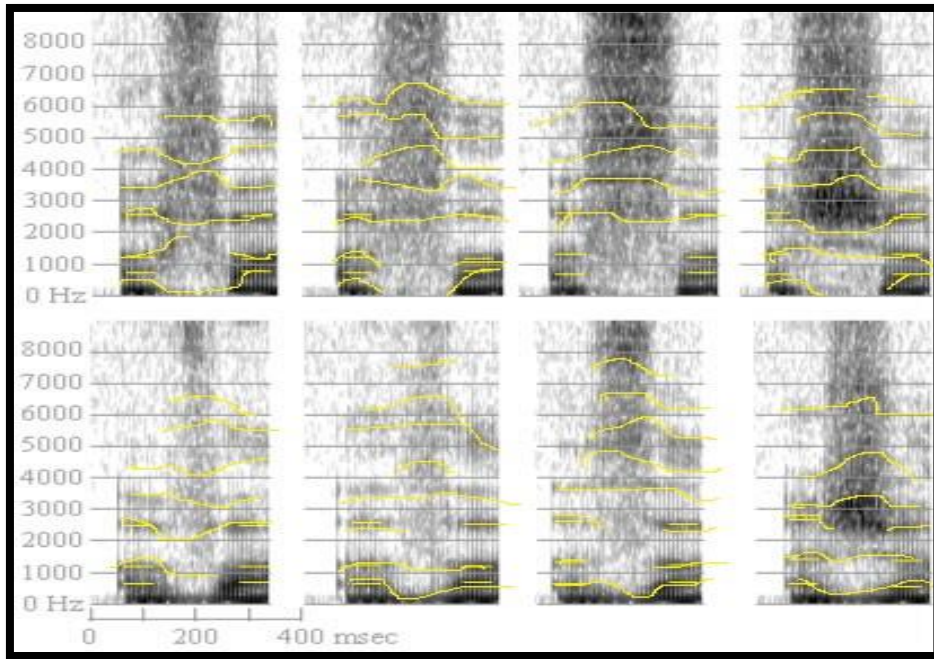
The acoustic analyses of the audio record are as follow:

Table (3) spectral analysis of kurdish young children with cross-bite malocclusion

Sound features	Sounds	Participant H	Participant I	Participant J	Participant K
Sound duration	/ θ, δ/	=(127- 128)	=(125- 127)	=(132-134)	=(129- 131)
	/s, z/	= (172-173)	= (170-172)	=(166-169)	= (171-173)
	/t,d/	=(115- 117)	=(113- 119)	=(119-124)	=(102- 127)
	/f,v /	= (141- 143)	=(141- 144)	=(140- 142)	=(139-140)
Frequency (F)KHZ	/ θ, δ/	= (3.9 – 4.5)	= (3.3-4)	= (3- 3,9)	= (3.5-4)
	/s, z/	= (3-3.5)	= (3.2-3.8)	= (2.9-3.3)	= (3.2-3.9)
	/t, d/	= (9-10)	= (8-11)	= (8-10)	= (8 – 9.5)
	f,v	= (1-8.2)	= (2- 2.3)	= (2- 2.3)	= (1.9 - 2.7)
Amplitude dB	/ θ, δ/ =	= (58-64)	= (58.9-65)	= (60-60)	= (59-61)
	/s, z/=	= ((9.9-12.5)	= (10-12.5)	= (9.9- 13.5)	= (9.5 -13)
	/t, d /	= (72-70)	= (73-70)	= (73-71)	= (73- 70)
	f,v	= (40-46)	= (43.3- 37)	= (42- 44)	= (43.4-48)

The results obtained from the acoustic analyses of the samples with the cross-bite occlusion, the Mesiocclusion, show that all of the participants have a serious problem with the pronunciation of / f, v/ sounds. In comparison with the standard range that are recorded by Boersma and Weenink. The sample produce the sounds /f, v/ with less duration amplitude and weaker frequency. Another feature of the sound production by the children with the bilateral cross-bite occlusion shows that the children with Mesiocclusion have difficulties in inserting their tip tongue between the upper and lower front teeth easily due to the shape of their teeth and lower jaw position. On the other hand, their production of / s, z, t, and /d / sounds are almost normal according to the reading of the spectrograph of their sound frequency, duration and amplitude. The following graphs show a part of single sound production by the participants with the mesiocclusions.

The below spectrograms show the production of the target sounds by children with deep bite occlusion:



Figure(10) samples of the sound wave of the participants

1. **To answer the second study question which states:** Which type of malocclusion has the most potential effect on the negative production of the target sounds?

The vocal graphs of children with malocclusion were compared to the audio analyses of children with normal occlusion. The result reveals that the participants with distocclusion, more precisely those who have 6-7mm space between the upper and lower front teeth, have greater problem in producing the alveolar, interdental and labiodental fricative sounds in comparison with the participants with neutroclusion and mesiocclusions. The spectrogram analyses of their sound production, as they are found in tables (1 &2), show that the durational characteristics of the mentioned sounds are shorter, and have weaker frequency.

The data obtained from the spectral analyses also indicate that the participants with extra-orally and intra-orally malocclusions have difficulty in pronouncing alveolar fricative sounds and inter -dental /s, z, θ, ð / in comparison with the children with other type of malocclusions due to protrusion of the front teeth,. In other words, they are unable to articulate sibilant consonants perfectly by adjust their mandibles (lower jaws) with up their upper front incisors to form a necessary jet for air to be produced with fiction. Whereas, the participants with cross-bite malocclusion have difficulty in pronouncing labio-dental sounds clearly due to hardness in forming suitable articulation between the lower lip and upper front teeth. So, they produce the sounds /f, v/ with less friction, less amplitude shorter duration and weak frequency. In addition, there are unable to produce stop alveolar sounds /t, d/ and inter- dental sounds/θ, ð/ appropriately and with adequate duration, frequency and noise. See table (3)

All in all, the children with distocclusion have the greatest difficulty in alveolar, inter, inter-dental, and mesiocclusions have imperfect pronunciation of some fricative stop sounds and labio-dental in comparison to the children with neutrocclusion or normal bite block occlusion.]

5.0 Conclusions

The current study examined the effect of different types of malocclusion on Kurdish young learners' production of inter-dental, labio-dental, and some alveolar sounds production. Based on the analysis of the vocal profile and spectrogram of the participants' sound pronunciation record, the following findings are drown:

1. Malocclusion is associated with speech sound production errors.
2. Kurdish young children with Distocclusion, both open-bite and deep- bite malocclusions have alveolar, inter-dental and labio-dental fricative sound production errors.
3. Children with open-bite malocclusion, with more than 6mm, face difficulties in producing the alveolar consonant sounds /s, z, θ, ð/ due to misalignment of the permanent teeth, lack of contact between opposing edges of the front teeth. In addition, the frictions of their production of the

- mentioned sound are slightly weak. While the children with deep-bite malocclusion, especially extra-orally occlusion, have problem with labio-dental sounds /f, v, s, z / more than /t, d/with regard to inappropriate the upper front incisors and mandible placement.
4. The obtained results from spectral analysis revealed that Kurdish children with Mesioocclusions are unable to pronouns labio-dental and inter-dental sounds /f, v, θ. ð/ more than / s, z, t, d / sounds due to their inappropriate mandibles and lower front teeth placement
 5. The sound production of children with open-bite and extra orally occlusions were more significant than other types of malocclusions in affecting sound production. The majority of the sound production errors produced by Participant F and G due to the lack of contact between posterior teeth edges and of the lack of lower lip involvement.

References

- Behrens, SH. and Blumstein, E, (1988). Acoustic characteristics of English fricatives: a descriptive analysis. *Journal of Phonetics* Vol 16, pp. 295-298.
- Edwards, J. (1992) Compensatory speech motor abilities in normal and phonologically disordered children, *Journal of Phonetics*, Vol 20, pp.189-207
- Green, J. , Moor, C. ,Reilly, K. (2002) The sequential development of jaw and lip control for speech. *Journal of Speech, Language and Hearing Research*, Vol 45(1), pp. 66-79
- Jongmanam, A. , Wayland, R. , Wong,S. (2000) Acoustic characteristics of English fricatives. *J. Acoust. Soc. Am.*, Vol. 108, No. 3, pp. 252-263
- Kaur, N. (2017). Effect of malocclusion on masticatory sound. *International Journal of Research in Health and Allied Sciences* ,Vol. 3, pp, 76- 81
- Lane, H. , Denny, M.; Guenther, F. H.; Matthies L.; Ménard, Lucie(2015). d, Effects of bite blocks and hearing status on vowel production" (2005) . *The Journal of the Acoustical Society of America*. Vol. 118(3) , pp 1636–1646
- Leavy,K., M., Cisneros,J., LeBlanc,B.E.(2018) Malocclusion and its relationship to speech sound production: Redefining the effect of malocclusal traits on sound production. *American Journal of Orthodontics and Dentofacial Orthopedics*. Vol 150(1), pp117- 123



- Nielsen, I.(1992) Vertical malocclusions: etiology, development, diagnosis and some aspects of treatment. Angle Orthod :61:247-60
- Ageet, A.O. (2016) classification of skeletal and dental malocclusion: revisited, *Stomatology EDU Journal*, Vol.3(2), pp, 38-44
- Wais, GH.F. (1984). Phonetics. (In Kurdish). Baghdad: Al-Adib Press.
- Proffit, W., Fields, H. , Larson, B. ,Sarver , D.(2019) Contemporary Orthodontics. 6th Ed. Philadelphia, Elsevier.
- Siegel, M. A matter of Class: Interpreting sub-division in a malocclusion. *AJO* 2002;122;582-6